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PROCEEDINGS OF THE

EIGHTH CONFERENCE ON MAPLE PRODUCTS

October 19—20, 1971
Boyne Falls, Michigan

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PREFACE

The Eighth Conference on Maple Products was held October 19 and 20, 1971, at Boyne Falls, Mich. For the first time since its inception in 1950, the triannual conference was moved away from the Eastern Marketing and Nutrition Research Division into maple country and was cosponsored by the maple sirup industry. The meeting was attended by representatives of the governments of the United States and Canada, State governments, State agricultural experiment stations, the extension services, and universities; maple producers, processors, and distributors; and equipment manufacturers. Names and addresses of the conferees are listed at the end of this report.

Mention of companies or commercial trade names in this publication does not imply endorsement by the U.S. Department of Agriculture over others not mentioned.

Opinions expressed by the participants at this Conference are their own and do not necessarily represent the views of the U.S. Department of Agriculture.

Underscored numbers in parentheses refer to references at the end of each paper. References, figures, and tables are reproduced essentially as they were supplied by the author(s) of each paper.

This report prepared at the

Eastern Marketing and Nutrition Research Division

Agricultural Research Service

U.S. DEPARTMENT OF AGRICULTURE

600 East Mermaid Lane

Philadelphia, Pennsylvania 19118

Issued February 1972

EIGHTH CONFERENCE ON MAPLE PRODUCTS

Boyne Mountain Lodge
Boyne Falls, Mich.

Program and Contents

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INTRODUCTORY AND WELCOMING REMARKS

Greetings were extended to the conference by Edward Curtis, President, National Maple Syrup Council. Mr. Curtis extended a welcome to the group from the Council and mentioned the highlights of its annual meeting which was held in conjunction with the conference. The need for better financial backing of the Maple Syrup Digest by maple producers was pointed out as the paramount concern of the Council this year. New maple sirup standards, the short supply of maple sirup, and container problems were other topics discussed at the Council meeting.

* * * *

After Mr. Curtis' remarks, the following welcome to the conferees was given by Dr. Jonathan W. White, Jr., on behalf of the U. S. Department of Agriculture:

WELCOME

Jonathan W. White, Jr.
Eastern Marketing and Nutrition Research Division
Agricultural Research Service, USDA
Philadelphia, Pa.

On behalf of Dr. Ivan Wolff, Director of the Eastern Marketing and Nutrition Research Division, I bid you welcome to this Eighth Conference on Maple Products. We hope that this conference, the first to be held away from our laboratory headquarters in suburban Philadelphia, will be as useful, interesting, and stimulating as the first, which was held in November 1950.

We welcome the opportunities to cooperate with the National Maple Syrup Council and with interested State organizations such as the Michigan Maple Syrup Producers in co-sponsorship of this continuing series of maple industry conferences. In moving the maple conferences away from our headquarters we are following the examples of such nationally recognized meetings as the National Potato Utilization Conferences, the Tobacco Chemists Conferences, and the Milk Concentrates Conferences, which started many years ago in our headquarters and are now held in various locations.

I don't know if there is anybody present who has attended all eight of these meetings, covering a span of 21 years. I do know that Fred Winch

is the only one who is on this year's program and who also spoke at the 1950 meeting. Two others, Bob Morrow and Ray Foulds, are on this year's program, and were also present in 1950, though not on the program.

We have had a small but active maple program for 23 years. We are very proud of the record of this research group, for so many years under the leadership of C. O. Willits and now, Clyde Underwood. It has clearly been the most productive unit at our Division in terms of accomplishments and publications, with some 137 papers issued to date. We want it to continue and to be responsive to your needs and to those of the maple producers, processors, users, and society as a whole. This means we must continue to keep in touch, to communicate. In this area, we have a problem, one that is not confined to us alone, but one bound to have an effect on this needed communication. This is, to put it simply, that we are in a continuing period of great financial stringency. We must restrict travel for all of our scientists and all requests for travel and meeting attendance must be examined and justified; many are denied simply because funds are not available.

Thus, our maple people will not be able to travel to your workshops and meetings as much as you or we would like. We are trying to get the best use of our funds and this may mean combining as many such meetings on as short a trip as practicable. We all hope that these conditions are temporary and we can look forward to better times. We want you to keep the problems and requests for information and advice coming in, and we will do our best to cope with them. Again, it's a pleasure to be here in Michigan and to welcome you on behalf of the Department of Agriculture.

* * * *

Representing the Michigan maple sirup producers, hosts for the conference, Mr. John Hodge, district extension leader, Resource Development, Michigan State University, welcomed the attendees to the area. Some of the entertainment possibilities of the immediate locale were pointed out, including the outstanding outdoor recreational facilities. A program for those ladies not wishing to attend the technical sessions was outlined.

SELECTION AND PROPAGATION OF SUPERIOR SAP SUGAR-PRODUCING TREES

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Introduction

I am sure that we are all aware of the significant advances that have been made in agriculture through genetic improvement both in plants and animals. These improvements are based primarily upon variation, differences in genetic makeup, which is the stock and trade of geneticists the world over. Occasionally, there is some misunderstanding as to how, or whether, this applies to trees. Let me ask you this question--have you ever thought of why a pine tree is different from an oak tree? Or why an oak tree differs from a maple? These are broad classes of trees and their differences are based on rigid genetic control with environment playing a relatively minor role in their phenotypic expression. However, within a species, such as sugar maple, genetic differences may be more subtle and procedures required to detect these differences more complicated.

The mission of the Northeastern Forest Experiment Station's Project at Burlington, Vt., is to develop more efficient methods of producing sugar maple sap. One of the objectives of the program has been the development of superior sugar-producing trees. One of the first major steps in attaining this goal has been the selection of sweet trees for use as foundation stock. This required a method that would insure that selected trees would owe their superiority in sap sugar production primarily to genetic rather than environmental effects.

The second step, one that we are presently completing, is the establishment of a clonal bank made up of grafts originating from selected trees. The clonal bank would protect against the loss of trees from destructive agents and would also bring the selections into a central location, making it easier to carry out future propagation work.

The report describes the selection program that was recently completed together with our progress to date in establishing the clonal bank.

We expected no problem in propagating selected trees through bud and scion wood grafting. Answers to letters of inquiry that we sent to four leading nurseries that propagated sugar maples for ornamental purposes led us to believe that we could expect up to 95 percent success with bud grafting and about 50 percent with scion grafting.

Background

There have been many sugarmakers over the years who knew of certain trees in their maple groves that had unusually sweet sap. In general, they also knew which neighbor had the sweetest sugarbush, and that one section of a bush may produce more sugar than another. Differences in time spent in boiling down sap often told them that in some years a sugarbush produces sweeter sap than in others.

Scientists have studied various characters that might influence sap sugar production, and it was generally concluded, though not unanimously, that trees with larger crowns produce sweeter sap (2, 3, 4, 6). This was not always the case, and when variability could not be explained by physical factors, the authors suggested that hereditary influences were at work (2, 3).

Differences in sap sweetness up to 100 percent have been reported between trees in the same sugarbush (5). Although sugar concentrations of an individual bush may change during the sap season and from year to year, sweet trees tend to maintain their superior rankings, relative to neighboring trees, during these changes (1, 5).

Methods

A preliminary study indicated that it would not be feasible for us to use the classical selection method of determining an average for a population and then selecting all phenotypes that exceeded the average by a given level. This method proved unworkable because the population average could not be proportionately weighted to account for such changes as stand density, site quality, and size and age classes of trees.

A new procedure was developed in which a single sample of 100 trees was taken in each sugarbush. Trees were not required to meet a predetermined absolute sugar value in order to be selected. Any tree was considered a superior phenotype which met the criteria of being at least 30 percent above the average of several, preferably 4, immediately adjacent standard trees and exceeded the sweetest of the standards by a minimum of 0.5 percent.

All selected trees and standards were suitably marked for later identification and tested at least twice more before being screened. Tests were completed as quickly as possible to prevent confounding of genetic variation in sap sweetness with variation due to changes in time. Test results were entered on individual tree-record forms together with the identification number of the tree, its location, and the name and address of the owner.

To evaluate the genetic potential of field selections, all selected trees were screened by a geneticist from our office. Each tree was subjected to a list of criteria designed to eliminate trees that owed their superiority primarily to environmental rather than genetic factors (table 1). The direct objective of the screening procedure was to develop an index number that was indicative of the degree of similarity in external characteristics between

TABLE 1.--Criteria assigned for determining index numbers for characters used in screening sugar maples selected for superior sap sugar production

Character of factor	Index No.	Limits
Diameter	0	± 0-10 percent of selected tree diameter.
Do------	1	± 11-20 percent of selected tree diameter.
Do------	2	± 21-30 percent of selected tree diameter.
Do------	3	± 31 percent and over selected tree diameter.
Height	0	± 0-10 percent of selected tree height.
Do----	1	± 11-15 percent of selected tree height.
Do----	2	± 16-20 percent of selected tree height.
Do----	3	± 21 percent and over selected tree diameter
Distribution	0	Within 0-25 feet of selected tree.
Do----------	1	Within 26-40 feet of selected tree.
Do----------	2	Within 41-60 feet of selected tree.
Do----------	3	Beyond 60 feet of selected tree.
Crown	0[1/]	Completely comparable to selected tree.
Insect damage	1	Some variation but still considered comparable.
Disease damage	2	Considerable variation, comparability questionable.
Topography	3	Not comparable to selected tree.

[1/] Criteria limits 0 through 3 assigned to each character crown through topography.

the selected trees and their corresponding standards. A small index number would indicate that they compared favorably, which would make sap sugar comparisons between them more valid and would give more confidence to predictions that the observed variation was of genetic origin.

From the list of screening criteria that was applied, it can be seen that a series of graduated penalties was imposed against the selected tree as it departed from the standards in appearance and in their local environment.

In conducting our grafting work, the scion wood for the clonal bank was collected when the trees were in deep dormancy, in mid-January and early February. Scions were side-grafted during the latter part of February on 2- to 3-year old potted rootstocks grown from local, open-pollinated seed sources. Successful grafts were held in a lath house for the first summer and then lined out in the nursery for the following year.

During the 4 years that the program was in operation there were 70 fieldmen who cooperated in the search for superior trees. There were 279 sugarbushes that were sampled over the 6-State area of Maine, New Hampshire, Vermont, Massachusetts, New York, and Pennsylvania (table 2). Over 21,000 trees were tested for sap sugar content from which 319 field selections were made.

TABLE 2.--Summary of survey-selection and screening results according to State

State	Sugarbushes surveyed	Trees tested	Field selections		Final selections[1/]	
	Number	Number	Number	Percent	Number	Percent
Vermont	102	7,426	126	1.7	18	0.24
New York	72	4,896	74	1.5	15	.31
Pennsylvania	44	3,671	29	.8	7	.19
Massachusetts	35	2,537	34	1.3	6	.24
New Hampshire	18	1,952	46	2.4	5	.26
Maine	8	598	10	1.7	2	.33
Totals	279	21,080	319	----	53	---

[1/] Final selections made after screening field selections.

In processing the data received from the fieldmen, the number of selections were reduced from 319 to 237. Causes for the reduction were (1) failure to meet the selection criteria as outlined, (2) obvious differences in characteristics between selected and standard trees that made them incomparable, and (3) an excessive amount of physical damage either from insect or disease attacks or from storms. In some instances it was impossible to locate the selected trees because of improper identification and in a few cases trees were cut by the owners. We had one case where the owner refused the use of a selected tree for experimental purposes.

Each field selection was screened in accordance with the criteria listed in table 1. The score for each tree, together with the degree of superiority in sap sugar production, was used to make 53 final or plus tree selections. These trees represented 1/4 of a percentage point of the 21,080 trees that were tested during the program.

It may seem that our selection and screening criteria were too severe and that the number of plus trees was too small for the large number of trees

tested. However, high selection intensity tends to improve the quality of the selections by eliminating many of those individuals that may owe their superiority primarily to environmental rather than genetic factors.

Because there were relatively larger numbers of field selections made in one State than in another, we initially felt that there might be genetic differences between States in the manner in which variation was distributed. Differences observed between States in the percentage of selections made by fieldmen were found to be statistically significant. However, before any inferences were made from this analysis, the field selection data were compared with the final selection data. A rank correlation analysis showed a poor relationship between rankings of States according to field selections and according to final selections (table 3). The inference was therefore made that the differences between States in the number of field selections made were probably due to differences in the way fieldmen applied the selection method rather than to genetic factors.

TABLE 3.--Ranking of States according to percent of field selections and final selections

State	Trees tested (No.)	Field selection		Final selections	
		Selected trees (Pct.)	Ranking	Selected trees (Pct.)	Ranking
New Hampshire	1,952	2.4	1	0.26	3
Vermont	7,426	1.7	2	0.24	4
Maine	598	1.7	2	0.33	1
New York	4,896	1.5	4	0.31	2
Massachusetts	2,537	1.3	5	0.24	4
Pennsylvania	3,671	0.8	6	0.19	6

A small scale exploratory study was carried out to uncover problems associated with the breeding of selected trees. The results have shown that the distance between the geneticist's home base and the selected tree poses a serious problem in trying to determine flower receptivity. Further complications resulted from fluctuating weather conditions that can delay or accelerate receptivity, making predictions of pollinating dates unreliable.

The problem might be solved by dividing the general selection area into zones of selected tree concentrations and establishing a base of operation within each zone during the breeding season. No tree in the zone would then be more than a 2- or 3-hour drive from the base. An alternative would be to wait until the select tree grafts in our clonal bank begin to flower,

which may occur between 7 and 12 years after grafting.

Although commercial nurseries have reported 90 to 95 percent success in bud grafting of sugar maples, we have had very little success with this method. This is probably due to the more vigorous growth of material used by the nurseries, and to a lesser extent, a better grafting technique. Because of the poor results with bud grafting, nearly all selected trees have been clonally propagated by scion wood grafting.

Our initial scion grafting efforts were mainly experimental to determine the type of graft that would give us the best results. Of the three grafting methods that were tried, the side graft was found to be superior to the whip or cleft graft for us. Using the side graft, we have been slowly building up our clonal bank, and at present there are representatives from 44 selected trees in the bank.

Our best grafting results came this year when we had 198 successful grafts for a 47 percent "take," but we have not been without our disappointments and problems. A number of grafts that were overwintered in a covered lath house were lost during a prolonged period of subzero weather. We have, on several occasions, traveled long distances to selected trees to collect scion wood only to find that the trees were growing too slow to provide satisfactory material for grafting. To prevent future winterkill, all potted grafts are now stored in a root cellar where the temperature rarely falls below freezing, and we have been applying fertilizer around the slow-growing selected trees in an effort to promote more vigorous vegetative growth.

The maximum differences between selected trees and the average of their corresponding standards ranged from 30 to 140 percent. To those of you who may be interested in the sweetest tree that was tested, the honor goes to a tree in Caledonia County, Vt., which had a reading of 10.6 percent with the sap dripping steadily from the spile. At this concentration it is hard to believe that it would require just 8 gallons of sap to make a gallon of standard weight sirup.

In summarizing, I feel that the selection program was a success. The excellent cooperation that we received from all organizations that we approached resulted in 53 final selections from 21,080 trees that were tested. The selection and screening methods that were used have given us a group of trees that I feel have the genetic potential to help in making a real contribution to the sugar making industry.

Literature Cited

(1) McIntyre, A. C.

1932. The maple products industry of Pennsylvania. Pennsylvania State University Expt. Sta. Bulletin 280, 47 pp.

(2) Moore, H. R., Anderson, W. R., and Baker, R. H.

1951. Ohio maple syrup; some factors influencing production. Ohio Agr. Expt. Sta. Res. Bul. 718, 53 pp.

(3) Morrow, R. R.

1955. Influence of tree crowns on maple sap production. N. Y. (Cornell) Agr. Expt. Sta. Bul. 916, 30 pp.

(4) Stevenson, D. D., and Bartoo, R. A.

1940. Comparison of the sugar percent of sap in maple trees growing in open and dense groves. Pennsylvania Agr. Expt. Sta., Jour. Series, Paper No. 989, 3 pp.

(5) Taylor, F. H.

1956. Variation in sugar content in sap. Vt. Agr. Expt. Sta. Bul. 587, 39 pp.

(6) Ward, W. W., and Trask, J. S.

1967. Maple tree characteristics studied relative to sap and sugar yield. Sci. Farmer 14(2): 11.

NATURAL VACUUM AND THE FLOW OF MAPLE SAP

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In 1967, Blum reported that 43 percent more sap was obtained from closed tubing installations on slopes than from open or vented tubing. He associated this increase with vacuum created in the closed tubing. Gains in sap yield from natural vacuum[1/] are especially important since the collection of sap is the most costly and least profitable phase of making maple sirup. Moreover, sap costs for a tubing network are mostly fixed costs; increased sap flow from natural vacuum represents added profit with little or no added cost. Recently, Laing et al. showed that sap produced under high vacuum conditions differed little in chemical composition from sap produced without vacuum. Both produced a sirup of comparable high quality.

While Blum's research results were exciting, they prompted numerous questions to which answers were needed prior to successful field application of natural vacuum and tubing techniques:

1. How do number of tapholes per tube line affect natural vacuum?
2. How does slope affect natural vacuum?
3. How do results vary by season and locality?
4. Where should vacuum be measured?
5. Is natural vacuum more effective at slow or fast flow rates?
6. What limits the production of natural vacuum?
7. What are optimum conditions for natural vacuum?
8. How does production with natural vacuum compare with pumped vacuum?

Our research commenced in 1968 with an initial attempt to answer the first two questions. In succeeding years it was extended to three localities and broadened in scope to gain information on the other questions. Altogether some 4,500 experimental tapholes were used. In addition, tests were made of water flow through tubing in 1970 and 1971 to gain theoretical knowledge concerning vacuum and flow rates so that results of field tests could be properly interpreted. All tests were made with commercial tubing with approximately 0.3 inch inside diameter.

Conclusions

Good natural vacuum in closed maple tubing needs the following:

[1/] Natural vacuum should be distinguished from pumped vacuum.

1. A good, leak-free installation and freedom from rodent damage.

2. A high column of sap to make a good head. An elevation difference of 50 feet or more is best. This can be obtained by steep slopes and/or long lines, as well as sufficient numbers of tapholes per tube line.

3. A fast flow rate, obtained by numerous tap holes per line; vigorous trees; good climatic and weather conditions for sap flow; etc. Within the range tested, vacuum increased with larger numbers of taps; ten taps per line were too few, while best vacuums were obtained with 50 or more taps.

4. Minimum sag in tube lines. Changes in elevation which restrict continuous downhill flow of sap will reduce vacuum in either aerial or ground tube lines.

5. Suitable slopes and proper numbers of tapholes. Five-percent slopes had good vacuums with 50 taps per line; additional taps would likely overload the line. Ten-percent slopes had the best vacuums; 50 to 80 taps were best. Fifteen-percent slopes were not as good as ten-percent slopes, probably because there were too few taps. We believe that a hundred or more taps per tube line are necessary for best results with 15 percent or steeper slopes. On such steep slopes, tubing can be installed at lesser slopes simply by angling it away from the direction of steepest topography. On the other hand, good installations are difficult on slopes of less than 5 percent, and we recommend the use of pumped vacuum where feasible. It is also important to avoid shallow slopes in the lower and middle portions of tubing installations.

Gains in sap production tended to be proportional to increased vacuum, whether natural or pumped. Both experimental and commercial results suggest seasonal sap gains of 1 to 2 quarts per taphole for each inch of vacuum (33 to nearly 100 percent). The lower gains are associated with natural vacuum, poor seasons, and low-producing localities and bushes. The better gains may be achieved with pumped vacuum, good seasons, and high-production trees.

Both the requirements for and potential sap gains from natural vacuum indicate the need for evaluation and proper use of slope for maple tube installations. Steep slopes, poorly regarded in the past, may now be considered assets.

Acknowledgments

The author acknowledges the generous aid and cooperation received from several sources. His thanks go especially to the following: Miner Institute, Chazy, N. Y., for its commitment of land, facilities, equipment, labor, a supervisor, and other resources to this research; Mr. and Mrs. Henry Uihlein for continuing gifts to the support of research; Mr. Lewis Staats, Resident Manager, Heaven Hill, for technical services in field research; Mr. Charles Hoag, Chief Forester, Miner Institute, for technical services in field research; Mr. Fred Fontana, Resident Manager, Arnot Forest, for technical services in field research; and Professor Cyrl Terry, retired, Cornell University for guidance and technical services in theoretical vacuum experiments.

VACUUM PRODUCING EQUIPMENT FOR

MAPLE SAP OPERATIONS[1/]

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The advantages of vacuum on the tubing lines of maple sap collection systems are well known to most of us. Within the past few years, several publications have appeared regarding use of vacuum pumps in maple operations. I'm sure many of you could verify the value of vacuum through the increases in sap yields which you have obtained on your own vacuum equipped operations.

Bob Morrow has told us about the development of vacuum in graded tubing installations where adequate natural slope is present to move the sap by gravity. Under favorable conditions, considerable natural vacuum may develop with the result being sizeable increases in total sap yield. However, there are many areas where natural slope is inadequate or in some places, such as many sugarbushes in Michigan and much of the Midwest, where little if any slope is present. In such areas, artificial vacuum is required for successful use of a vacuum-assisted tubing system. In other areas where minimum slope is present, the use of vacuum pumps may be necessary to increase or add to any existing natural vacuum.

There are several types of equipment available that can be used to produce vacuum. We will consider each of these, together with their advantages and disadvantages. However, before doing this, we will look at some of the requirements of vacuum pumps (systems) for maple sap operations.

Requirements of Vacuum Pumps (Systems)

1. The pump used must be capable of developing a large amount of vacuum. Some evidence is available which indicates a direct relationship between the amount of vacuum present at the taphole and the sap yield obtained.

2. Vacuum must be transmitted from the source to the tree. The transmission of vacuum from the pump to each individual tree must be completed before increases in sap yield can be obtained. This requires the use of a closed tubing network that will carry the vacuum from the source to the taphole and the sap back from the tree to a collection facility.

[1/] Presented by L. E. Bell, Extension Forester, Michigan State University.

3. Some provision must be made to separate the vacuum from the incoming sap at the collection point. This is more of a problem with certain kinds of systems and will become more apparent when we discuss types of vacuum systems.

4. The vacuum unit should be as reliable and simple to operate as possible. Furthermore, it should be able to withstand periods of low temperature without damage. In this respect, some units may require protection from freezing for part of the time.

Types of Vacuum Pumps (Systems)

Any system which will apply vacuum to the taphole of the tree should result in an increase in total sap yields. However, under practical applications there are only three types of pumping units available for use. We will consider each of these individually, together with some of their advantages and disadvantages.

Dry Units

In its simplest form, this type of unit is most easy to understand, but may be more difficult to apply or operate under field conditions than units of some other types. An ideal dry unit might be as follows. A large, heavy gauge tank is evacuated so it can serve both as a vacuum reservoir and a sap storage tank. The source of vacuum is obtained by a compressor which evacuates the tank through a small opening on the top side. The main line of tubing from the field tubing system enters the tank at the opposite side. When the unit is in operation, sap enters through the tubing lines and collects in the tank. As the level of sap in the tank rises, it may eventually be necessary to empty the tank, either by gravity or by pumping. Normally the vacuum must be turned off during the emptying process. While this system has the advantage of being simple, it has the disadvantage of requiring a large, reinforced tank to collect the sap,and provision must be made for emptying the tank when it is full, thus interrupting the transmission of vacuum to the trees.

A more common adaptation of this system is the use of a smaller tank equipped with a dumping unit. Under these operations, a compressor-type pump is used to evacuate a small container (10 to 20 gallons). From this container, sap lines extend to the field. As sap enters the tank it raises a float device which, when a certain level of sap is reached, turns the pump off, opens a sap escape valve, and permits the sap to drain into a large storage tank. As the float drops with the emptying sap, the pump is again started, the release valve is closed, and vacuum is again applied to the field lines. This unit is more efficient than the larger single tank, but has the disadvantage of not developing high vacuum levels due to the frequent emptying of the tank.

A modification of this system has been developed which employs a

compressor type pump to evacuate a small (20-to 40-gallon) tank. Field lines extend from this tank to the field. As sap enters the tank, it raises a float device. When a pre-set level is reached, this float trips a switch, turning on a small centrifugal pump which empties the tank. This pump operates against the vacuum present; thus the supply of vacuum to the field is not interrupted. As the sap level in the tank falls, the float drops, turning off the emptying pump. When the tank fills again, the emptying cycle is repeated. With this system, it is possible to maintain high-vacuum levels during all phases of operation.

Wet Units

Pumping units which create a vacuum by pumping water through a jet (Venturi) unit are referred to as wet units. Such a system creates a vacuum by pumping liquid from a reservoir through a pump and on through the well-jet unit back into the reservoir. The jet unit is so constructed that a vacuum is created on a side outlet when liquid is circulated through the pump. When applied to sap collection systems, the main tubing line is connected to this outlet, thus transferring the created vacuum to the tapholes through the tubing lines.

Sap enters the line and passes through the jet unit on into the collection reservoir. In some installations, the reservoir may also be the sap storage tank. In others, incoming sap may flow from the reservoir into a separate storage tank.

This system has the advantage of being simple in concept and efficient in developing a high vacuum level. Its principal disadvantages include: (1) it requires protection from freezing since a reservoir of sap is required for operation, and (2) some deterioration of sap quality may occur due to heating of the sap when it passes through the pumping unit. This latter problem is more critical during periods of low flow when small volumes of sap are being obtained from the trees.

Gear Pumps

A third type of unit that can be used to develop vacuum on tubing lines is a gear pump. This application is perhaps the simplest of all operations but may not be as efficient as other type units. The reason for this is that vacuum will not be present unless sap is in the line; therefore high levels of vacuum are not likely to be developed. While this unit may be helpful in moving sap through main tubing lines, it probably is not too efficient in transmitting high vacuum levels to the tapholes during small or weeping flows or to large systems where much tubing is present. By way of interest, it is generally believed vacuum pumps are most effective in increasing total sap yields when they are operated during so-called weeping flow periods.

Vacuum Applications

Thus far we have discussed the types of equipment available for vacuum

purposes. I think that most of us are convinced that vacuum will result in larger total sap yields, and the question then is, "How do you get vacuum to work satisfactorily on your sugarbush?" As with many things, the idea is often simpler than actual installation under field conditions. However, it is in the field that the value of vacuum can and must pay off for the sap producer.

For small systems (less than 500 to 700 taps), it is fairly easy to design a tubing system and attach either a dry-or wet-type pump. However, in larger operations, the problems become more complex as the number of taps and the size and length of tubing required increase.

It is more difficult to pull sap through a line than to push it, and for this reason, some producers have been disappointed with yields from vacuum operations, particularly on large installations. In such setups, the lines often fill up with sap, and vacuum developed by the pump is lost before it can reach the tapholes. As mentioned before, for vacuum to be most effective in increasing sap yields, it must be extended to each taphole.

For smaller operations, sufficient vacuum can probably be transmitted through 3/4-inch main conduit to increase sap yields. This is especially true if some natural slope is present and the length of the main line is not too great. On larger installations which are connected to a 1,000 or more taps, a modification may be necessary. Such a system has been called vacuum transfer, and essentially what it does is to make several small units out of a large setup. It is effective in avoiding the vacuum loss in the main lines while at the same time transferring the vacuum more directly to the tapholes. This transfer of vacuum is accomplished by using a small vacuum tank (similar to the dry type unit) at the end of the main line where the collection tank is located. This tank is equipped with a dumping unit and the main conduit is attached to one side. A small (5/16- or 1/2-inch) line is attached near the top of the tank and extended along the main sap line toward the sugarbush. If a long line is used at the beginning of the sugarbush, or if several hundred taps converge at some location on the conduit in the sugarbush, a vacuum separation unit is installed. This consists of a small (10 to 15 gallons) tank to which the main conduit is attached at the bottom on the downhill side. The other end of the conduit is attached about one-half or two-thirds of the way up on the opposite side of the tank. The small vacuum line is attached to the top of the tank.

This system operates by creating a vacuum on the dumping tank with either a wet or dry unit. Some will be transferred along the main conduit and will reach some of the tapholes on the lower end of the setup. It will also assist in moving sap through the lines. Additional vacuum will be transferred directly to the upper tank where it will be conveyed directly through the smaller lines. Sap entering the tank will continue on through the tank and exit into the main line. Provided sap does not enter faster than it leaves, the vacuum only line will not contain any sap. If a larger system is present (2,000 to 3,000 taps or more), it may be advisable to place two or more separate vacuum transfer units in the system to move the sap and transmit vacuum efficiently throughout the system.

I have talked about different types of vacuum pumping units and how these can be applied to field conditions. Some may appear complicated, but are really quite simple when compared to the increasing cost and scarcity of labor and the necessity to maximize sap yields. Vacuum pumps can and do work. Their success is dependent on how well you as a producer are able to transfer the developed vacuum to the taphole where it is required. When this is efficiently completed, vacuum pumping will probably be one of the most beneficial improvements maple sap producers can make to present sap collection systems.

PHYSIOLOGICAL EFFECTS OF

HIGH VACUUM PUMPING

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Introduction

Vacuum pumps have been used for over ten years to increase the flow from maple trees. At first (1, 2, 3) it was not recognized that a gravity, closed, 18-inch drop suspended system properly installed on a reasonable slope would generate an appreciable vacuum. Thus, using low vacuum pumping (<15 inches of mercury), little difference in yields was found between gravity system and pumping. Morrow recently reported on natural vacuum and pumped yields (5). More recently we have been using high vacuuum(>15 inches of mercury) and the yields are much greater than from the natural vacuum controls. Our data from 1970 and 1971 are shown in table 1. The increase was 72 percent in 1970 and 46 percent in 1971. The vacuums produced averaged 18 inches of mercury, as continuously recorded at the pump by a recording potentiometer. Similar data collected by Morrow and Gibbs (6) for 50 tap experiments gave increases with high vacuum of over 100 percent.

TABLE 1.--A comparison of yields of sap from gravity and high vacuum tubing systems

Source and year	Gravity		Pumps		
	Number of taps	Gal./tap	Number of taps	Gal./tap	Min. vacuum (inches Hg.)
Proctor Maple Research Farm:					
1970	734	9.61	609	16.70	15 inches
1971	832	9.75	775	14.18	15 inches
U.S. Forest Service: *					
1969	50	4.1	50	10.9	15 inches
	50	4.6	50	10.1	15 inches

*Morris and Gibbs (6).

It appears clear from these data and other similar data from the Forest Service group and from Morrow that high vacuum pumping gives greatly increased yields over gravity--extracting sap from the trees--and that it is the most effective method of collecting sap at the present state of the art.

Results

When we recognized that high vacuum pumping extracted sap from the taphole, it became imperative to determine whether there was a change in the composition of the extracted sap. Vacuum extraction could increase the amount of water, thus producing a more dilute sap, or it could cause an increase in all the solutes, or selectively increase some of the solutes in the sap. Further, we did not know whether high vacuum pumping affects the color and quality of the sirup (4).

The sugarbush at the University of Vermont Proctor Maple Research Farm, Underhill, Vt., has a capacity of about 1,400 taps. In 1970, 1,343 taps in the bush were divided unequally into four quarters designated A-338, B-395, C-271, and D-339. Tubing was installed in all quarters as an 18-inch drop, nonvented, suspended system. Quarters A and C were vacuum pumped; B and D were gravity controls. Quarter A was pumped with a wet jet-type vacuum pump and Quarter C by a dry Mitchell-type pump. The vacuums produced and the volume capacities of the pumps were essentially the same. Vacuum levels at the pumps were monitored continuously by pressure transducers recorded by a strip chart potentiometer.

During the sap-flow season, March 19 to April 25, on every one of the 22 sap-flow days, we collected 6 aliquots of 4 liters of sap from the pipeline from each quarter. Two duplicate aliquots were reduced to sirup, two were used for chemical analyses, and two were frozen for future study. The analyses included: sucrose concentrations determined as total solids with a hand refractometer; invert sugars as percentage values by a standard method; amino nitrogen content as parts per million by a ninhydrin method (1); phenol-reacting compounds as p.p.m. by a Folin method (5); and calcium, magnesium, potassium, phosphorus, sodium, iron, and manganese as p.p.m. by standard methods. The pH also was measured for each aliquot. Since the values obtained from the sap analyses and sap volumes were equivalent for the wet- and dry-pumped quarters A and C, as well as for the two gravity quarters B and D, we combined and averaged the data for both.

Sap Volumes

The average volume yield from 734 gravity flow taps was 9.61 gallons per tap, and the average from 609 vacuum-pumped taps was 16.70 gallons per tap. Statistically a very significant difference in volume exists between gravity and pumped taps ($P < 0.025$, where P is the probability of a more extreme T value).

Sucrose

The sucrose concentrations were slightly higher in gravity samples than in pumped samples. The greater difference was 0.3 percent on April 19, within the experimental error of our method. Sucrose concentration in all samples decreased from April 23 to April 25, markedly so, for the pumped samples.

Invert Sugars

Until April 19 the invert sugar concentrations in the pumped and gravity samples were essentially the same. After April 19 the invert sugar content of the gravity samples increased markedly. But the invert sugar content of all samples increased as the season progressed. This well-known seasonal increase results from biochemical changes in the tree and the hydrolysis of sucrose to invert sugars by microorganism activity in the sap brought about by higher temperatures late in the season.

Amino Nitrogen

The procedure employed in 1970 did not give useful results. A modified method utilized in the 1971 season indicated that the concentration of amino nitrogen was essentially the same in pumped and gravity samples. Early and midseason low values, in both systems, were followed by a rapid increase at the end of the season.

Phenols

The phenol-reacting compounds showed a slight seasonal increase. Results from pumped and gravity samples were essentially the same until the end of the season when the concentration in the pumped samples decreased more than in the gravity samples, similar to the decrease of sucrose values.

Mineral Elements

Concentrations of the calcium, potassium, and magnesium in the pumped samples and the gravity samples were the same. Each element increased rapidly in content--from early-season low values to a plateau--until the end of the season when we again found a rapid decrease in the content of both sap samples. The phosphorus concentrations were similar in the pumped and gravity samples; they exhibited a wide fluctuation with 3 maxima and 3 minima from March 26 to April 23, after which both gravity and pumped sample values decreased, as was noted with sucrose, phenols, calcium, potassium, and magnesium. Sodium values were very low except the instances that reflected residual sodium from a sodium hypochlorite solution used at various times in washing the equipment. Similarly, iron values were very low for both pumped and gravity samples until

April 1. After this date the values from the pumped samples increased, no doubt reflecting iron derived from the pumps. Manganese was the only element monitored whose concentration was consistently lower in the pumped samples than in the gravity controls. Both samples showed the characteristic sharp end-of-season drop from early season values.

pH

Both gravity and pumped samples became more acid as the season progressed. This may be due to a seasonal increase in organic acids, four of which have been previously identified: malic, citric, succinic, and fumaric. Malic is 10 to 100 times more abundant than the others. Carbon dioxide also contributes to the acidity of maple sap as carbonic acid. The reduced pressure of the vacuum-pumped sap would make carbon dioxide less soluble; this solubility effect could explain why the pumped sap had a higher pH than the gravity sap.

Sirup Quality

Up to April 6 all sirup samples were Fancy grade. On April 6 and 7 pumped samples produced borderline grade A sirup. From April 18 to the end of the sap season, the boiled sap produced grade B sirup, probably because of an increase in seasonal temperature and microorganism activity.

Results from the analyses made during the 1971 season are essentially similar to the 1970 results.

To relate the analyses of pumped and gravity sap to sirup color and flavor, we had to reduce to sirup small quantities of sap collected separately from each quarter. We found that 2 liters of sap could be reduced to 50 milliliters of sirup in 70 to 90 minutes. A 500-milliliter aliquot of the sample was placed in each of four 2,000-milliliter beakers on a large gas-heated steel plate. When the 500-milliliter aliquots were reduced to 100 milliliters eacn, they were combined and reduced to about 50 milliliters of standard sirup, as determined with a temperature-compensating hand refractometer. Samples prepared in this manner are comparable in color and flavor to sirup from sap collected from the entire sugarbush and processed in a commercial 5-by-12-foot evaporator.

Discussion

The health and vigor of producing maple trees is of utmost importance. We have found that high vacuum *per se* does not injure trees, and it has an important additional effect in that paraformaldehyde pellets are not necessary (8). High vacuum without pellets gave increased yields over high vacuum with pellets. The work of Shigo and Laing (7) and Smith *et al*. (9) has conclusively shown that the use of paraformaldehyde pellets destroys the normal protective mechanism in the trees, which inhibits stem rot producing fungi, thus

opening the wound (the taphole) to possible infection.

The mechanism by which high vacuum is able to extract sap in quantities greater than the volume that would otherwise be obtained by normal tree pressure is of considerable interest. For many years we have continuously recorded the sap flow and the sap pressures in the wood near tapholes. Some flow periods are high pressure flows (10-20 pounds per square inch); others result from very low pressures (less than 1 pound per square inch). We call these low-rate flows weeping flows. During these periods of low internal sapwood pressure, the high vacuum effectively extracts sap from the vessels in the sapwood.

Summary

1. High-vacuum pumping (more than 15 inches of mercury) on a large number of taps increased sap volume by 73 percent over gravity flow.

2. The volume of sap and the quality of sap and sirup were essentially similar, whether from wet jet-type pumps or dry pumps.

3. High-vacuum sap produced high-quality sirup, comparable with sirup made simultaneously from gravity-flow sap.

4. High-vacuum pumping apparently did not alter the chemical composition of the sap, except for differences in the manganese values.

5. High-vacuum reduces the taphole infection that causes the tapholes to "dry up" and thus the need for taphole pellets.

6. In part, the effect of high-vacuum is to extract sap from the wood tissue during flow periods of very low internal pressure that would otherwise be weeping flows.

Literature Cited

(1) Laing, F. M., Lighthall, M. T. G., and Marvin, J. W.

1962. Studies on pipeline systems for gathering maple sap. Progress Report #1, Vt. Agr. Exp. Station Misc. Publ. 17.

(2) _______, Marvin, J. W., and Chamberlain, W. J.

1964. Results and evaluation of new maple techniques. Progress Report #3, Vt. Agr. Exp. Station Misc. Publ. 42.

(3) _______, Marvin, J. W., and Lighthall, M. T. G.

1962. Effect of new techniques on maple sap yields. Progress Report #2, Vt. Agr. Exp. Station Misc. Publ. 20.

(4) Laing, F. M., Marvin, J. W., Morselli, Mariafranca, et al.

1971. Effect of high vacuum pumping on volume yields and composition of maple sugar. Vt. Agr. Exp. Station Research Report MP 65.

(5) Morrow, R. R.

1969. The application of vacuum in sugar bushes. Dept. of Conservation, Cornell University Research Series No. 1, Ithaca, N. Y.

(6) _______ and Gibbs, C. B.

1969. Vacuum pumping doubles maple sap yield on flat land. U.S. Forest Service Research Note NE-91.

(7) Shigo, A. L. and Laing, F. M.

1970. Some effects of paraformaldehyde on wood surrounding tapholes in sugar maple trees. U.S. Forest Service Research Paper NE-161 and Vt. Agr. Exp. Station Journal Article 229.

(8) Smith, H. C. and Gibbs, C. B.

1970. Paraformaldehyde pellet not necessary in vacuum-pumped maple sap system. U.S. Forest Service Research Note NE-118.

(9) _______ Walker, E. B., Shigo, A. L., and Laing, F. M.

1970. Results of recent research on the pellet. National Maple Syrup Digest 9(4): 18-21.

FIELD TESTING THE EUROC

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In 1966 and 1967, laboratory-scale studies were made which indicated that reverse osmosis (R.O.) could be used for the partial concentration of maple sap. It was found that up to 75 percent of the water could be removed from sap at an estimated energy cost of about 1/20 that of the conventional atmospheric boiling process, and since the precursors of maple flavor did not pass through the semipermeable R.O. membranes, the R.O.-concentrated sap could then be further concentrated by boiling to yield a sirup possessing typical maple flavor and color.

Based on the results of these studies, the EUROC reverse osmosis unit was constructed for the purpose of conducting studies in the field under typical maple evaporator plant conditions. This unit was similar to the R.O. units using rolled membrane modules in current use for the production of potable water from brackish water sources. But in the case of potable water production, the water which passes through the membrane (called the permeate) is used for human consumption, whereas the maple producer is interested in utilizing the concentrated sap retained by the membrane for sirup production. Since the EUROC operated as a closed system and the process of sap concentration obviously served to concentrate the bacterial population of the sap, the unit design, unlike that of potable water units, included a battery of four in-line ultraviolet germicidal lights mounted in the feed line on the in-take side of the high-pressure pump. Passage of raw sap through the UV irradiation system resulted in a decrease of more than 95 percent of the bacterial population in the sap and thereby decreased contamination of the closed pressure vessels of the EUROC.

In 1968, the EUROC was tested at the central evaporator plant of Lloyd Sipple at Bainbridge, N. Y., under typical commercial operating conditions. In this work, it was shown that sirup made from R.O.-concentrated sap was equal in flavor and color quality to sirup made from the same lot of raw sap by conventional processing methods. Sanitation studies carried out as part of this program showed that during 36 hours of operation with a raw sap feed of good sanitary quality, bacterial counts of both permeate and concentrate effluent streams decreased during the first 12 hours of operation and then increased slowly for the remainder of the run. However, during this work, no impairment of operating efficiency due to a buildup of microorganisms was noted.

In the course of this field test, 10,000 gallons of sap were concentrated by passage through the R.O. unit at a feed rate of 5 gallons per minute and 500 p.s.i.g. pressure. Fifty percent of the water was removed from the feed, and there was no evidence that sap concentration by reverse

osmosis had any deleterious effect on the finished sirup made from this sap. No operating problems were encountered, and the major problem appeared to be the maintenance of sanitary conditions in the closed R.O. system.

During this season and for the remainder of 1968, sanitation studies were made to determine methods for maintaining the EUROC in good sanitary condition during periodsof idleness. When the unit stood idle for periods of time ranging from overnight up to three days without cleaning, bacterial growth took place in the pressure vessels. Because of this, a sanitation routine was developed to protect the membranes from deterioration due to microbial action. At the end of a run, the unit was washed and sanitized by pumping a hypochlorite solution containing 50 p.p.m. available chlorine, acidified to pH 4.5 with glacial acetic acid, through the unit for 20 minutes at 6 gallons per minute and 450 p.s.i.g. The germicidal solution was then washed from the membranes with sterile water to flush out the residual chlorine flavor. This system was effective but large volumes of water were required for flushing to rid the effluent streams of the hypochlorite flavor.

Late in 1968, a newly designed membrane module became available. This module was more rigid than the original modules and therefore more resistant to compaction at operating pressures. It was 3 feet long compared to the 1-foot length of the original modules, and it was designed to give a 50 percent increase in flux rate and longer membrane life. When the EUROC was field tested in 1969, two of its pressure vessels were fitted with the 3-foot modules.

The 1969 field tests were made at B. F. Walters' central plant at Mountain Meadow Farm, Schellsburg, Pa. The EUROC was emplaced and test run by EMN personnel. Then plant operators were trained, and they operated the unit during the season. Over 50,000 gallons of sap were passed through the EUROC at a feed rate of 6 gallons per minute and 550 p.s.i. pressure, and an average of 50 percent of the water was removed from the sap during the 4-week period of operation. The unit concentrated sap efficiently during the first two weeks operation. Then there was a progressive decrease in the amount of water removed from the sap until only 33 percent of the water was being removed. Analysis of the permeate stream indicated that there was no change in the quality of the water removed from the sap. The problem was simply a decrease in the amount of water passing through the R.O. membranes. A pressure tube was opened and examination of the modules showed a heavy deposition of slime on the membrane surfaces. Cleaning the unit with enzymic detergents and flushing with water produced only a temporary improvement.

The EUROC was returned to Wyndmoor where studies were conducted to find the source of this problem and to develop methods to eliminate or minimize it. Bacterial counts made on the concentrate effluent stream were high but not on a scale usually associated with slimes ($>10^8$ per ml.). Microscopic examination of smears taken from membrane surfaces revealed no long chains of encapsulated cells usually associated with slime formation in liquids, e.g. milk and juices; but the background debris observed on all slides examined had a mucoid appearance. Thus, it was possible that the major cause of the membrane fouling was a naturally occurring slime in the sap with a minor contribution to the problem stemming from slimes of bacterial origin.

The new modules did not have as heavy slime coatings as those noted on the original 1-foot modules. Since it had been determined that the flux rate through the new modules was 50 percent greater than that of the old modules, it appeared that the scouring action of the more rapid, turbulent sap flow through the new modules tended to keep slime deposits from forming as rapidly on these membranes as on the membranes of the 1-foot long modules.

Because of these observations, work was planned for the 1970 season to study the effect of a better balanced feed flow rate and lower operating pressure on the slime deposition and to investigate the source of the slime problem.

The EUROC was operated again at B. F. Walters' Mountain Meadow Farm during the 1970 maple season. The unit was operated at this plant for the second year because Mr. Walters, being very interested in the R.O. process, generously provided a number of the new 3-foot modules for the unit. Thus, it was possible to arrange the pressure tubes in a group of four parallel, 2-tube units connected in series. This arrangement provided 1,000 sq. ft. of membrane surface--600 sq. ft. in the 3-foot modules and 400 sq. ft. in the old 1-foot modules--and gave a faster, better-balanced flow through the unit than the parallel tube system used in 1969.

One hundred thousand gallons of sap were passed through the unit at 6 gallons per minute and 450 p.s.i.g. Concentrate was discharged directly to an evaporator pan for finishing to sirup. The rate of water removal from the feed ranged from 67 to 33 percent with an average of 49 percent. This constituted efficient operation at the 450 p.s.i.g. pressure used. As the season progressed, the problem of membrane sliming was encountered again. The problem appeared in midseason and intensified until the season came to an end. Cleaning the rolled-membrane type module used in the EUROC was most difficult, and for this reason, the rolled module may not be the best type for sap concentration. Some of the tubular-module units might be less susceptible to fouling or easier to clean and should be given a full season of trial operation on a plant-size scale. Of course, operation of any type R.O. unit could be helped greatly if a means could be found to remove the slime component from raw sap before it is fed to the unit. However, the slime problem affected only the amount of water removed from the sap. At all times, the rejection of sugar by the membrane was satisfactory. The loss in operating efficiency was due to sliming (or blinding) of the membrane and in no way due to membrane failure.

When the EUROC was returned to the laboratory after the 1970 season, the unit was serviced and given a series of test runs. At this time, it became apparent from conductivity tests of the permeate that the old, 1-foot modules were failing. Individual modules were tested and defective ones replaced, but as tests continued, more failures took place. It could not be determined whether this was caused by failure of the membranes or breakdown of the other module components, but it was obvious that the 3-year-old modules were no longer usable.

The present status of reverse osmosis processing in the maple industry can be summed up as follows:

1. R.O. will remove water from sap efficiently, and the processed concentrate can be boiled down to a sirup of quality equal to that produced by atmospheric boiling of sap from the same source.

2. Module designs other than the rolled configuration used in this work should be tested throughout a full maple season.

3. The feasibility of alternate application of R.O. equipment--whey concentration, etc.--should be investigated, as well as short-term leasing of R.O. units.

4. New and improved membranes and modules should be investigated from the standpoint of sanitation and membrane preservation.

5. Work is needed on naturally occurring slime components in sap and slime-forming microorganisms utilizing sap as a growth medium to find methods of eliminating R.O. membrane blinding.

6. More study is needed on methods for preserving membranes and modules during prolonged periods of idleness. At present it is not known whether the modules can best be preserved in place in the pressure tubes, or whether they should be removed from the tubes for separate storage in a preservative solution.

PARTIAL CONCENTRATION OF MAPLE SIRUP

BY REVERSE OSMOSIS

A Test Performed at Reynolds Sugarbush
Aniwa, Wis.
April 8, 1970

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Summary

A 7-hour test run was performed on 900 gallons of maple sap, utilizing the Aqua-Chem portable reverse osmosis demonstrator. The sap was concentrated from 3.3 percent solids to 14.5 percent. The total oxygen demand of the water removed was less than 1 part per million (p.p.m.) for every 2,000 p.p.m. in the sirup.

The test ran smoothly without incident. Power usage was about 10.8 kilowatt-hours (K.W.H.) per 1,000 gallons of feed. Membrane life is estimated at a minimum of four years at a replacement cost of $2.00 per square foot of membrane, if suitable sterilizing and storage procedures are used.

An analysis of the test data shows that the concentration rate can be increased by 50 to 80 percent by use of "looser" membranes. The product water from these membranes will contain approximately 1 p.p.m. of total oxygen demand (TOD) in the sirup. The concentration rate will be increased from approximately 7.3 gallons per square foot of membrane per day (g.p.s.f.d.) to 11 g.p.s.f.d.

A production unit has been designed to process 10,000 gallons of 3 percent sap in a <u>16</u>-hour period. The 10 percent concentrate would be discharged at a constant rate of 3 gallons per minute (g.p.m.). The selling price of such a unit will be $16,000 to $17,000.

It remains for those more closely acquainted with the maple sirup supply and demand to determine the cost justification for such a system.

We want to thank Mr. Aden Reynolds for his friendly cooperation. The serving of a buffet lunch and constant influx of those associated with the maple industry and their families caused the day to take on the appearance of a maple festival. Dr. Ted Peterson, Department of Forestry, University of Wisconsin, was also very helpful in explaining some of the facts about the industry.

Description of Test

A portable self-powered reverse osmosis test rig is shown in figure 1. On the near side are located, from left to right, the gas tank, an auxiliary power unit, 7-horsepower gasoline engine, and the Triplex positive displacement pump. On the far side are located the module and the membrane bank, containing sixteen 36-tube, 8-foot long modules. Only 10 of the modules were used during this test.

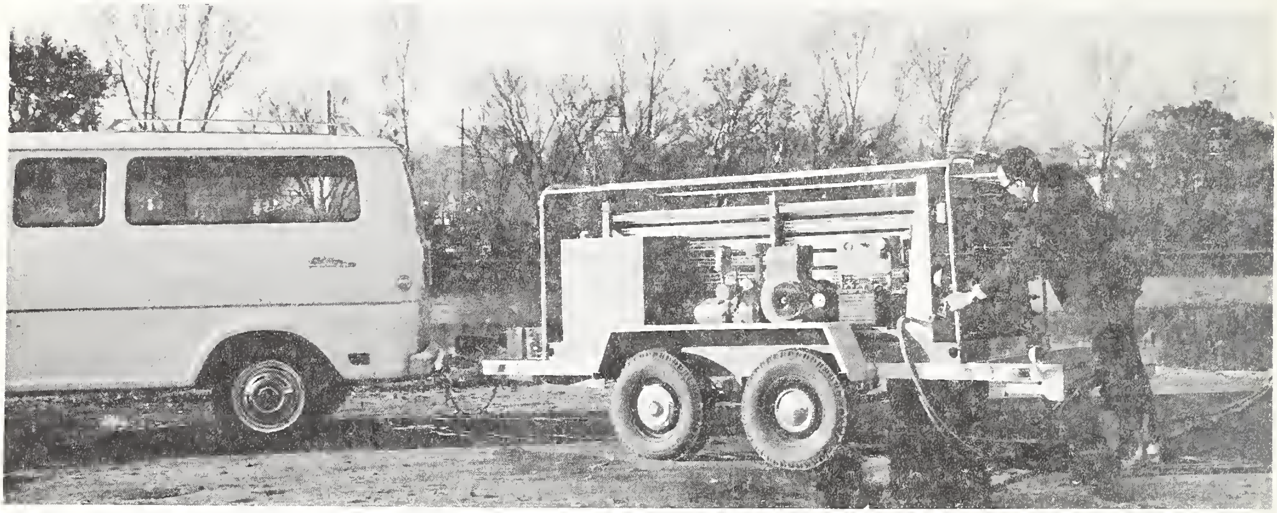

Figure 1.--Portable reverse osmosis demonstration unit.

The module manifolding is located to the right center, which permits the sap to enter the modules and sirup and water to emerge. The left end of the module bank is open to permit removal and replacement of the membranes in their carrier tubes, if required. The membranes used are considered to be "tight," since they have sodium chloride rejections in excess of 96 percent. Three hundred and sixty square feet of membrane were used.

The flow diagram, figure 2, shows the circuit utilized for the test.

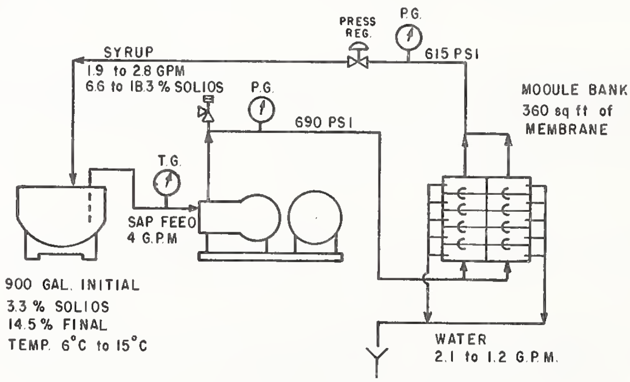

Figure 2.--Flow diagram of test run.

The stainless steel open top tank contained approximately 900 gallons of 3.3 percent sap at a temperature of 43° F. The sap was fed into the Triplex pump at the rate of 4 gallons per minute. From the pump, the sap was forced into the modules containing the tubular cellulose acetate membranes. The water, having permeated through the membrane, was removed from each module via a plastic tube into the water manifold. The water flow rate varied from 2.1 g.p.m. at the start of the test to 1.2 g.p.m. during the final minutes. The sirup concentrate was dropped to atmospheric pressure through the pressure regulator and circulated back to the supply tank. The sirup flow rate varied from 1.9 g.p.m. at the beginning of the test to 2.8 g.p.m. as the solids content of the sirup increased to 18.3 percent.

The duration of the test was 7 hours and the final tank concentration was 14.5 percent solids.

The test ran smoothly, without interruption. Samples of the feed, water, and concentrate were taken at the beginning, end, and four times during the run for laboratory analysis. These were used to determine total solids by evaporation. Data on flow rate, pressure, temperature, pH, specific gravity, and percent solids by refractometer were taken approximately every 45 minutes.

Test Results

The concentration data are shown in table 1. Since the temperature of the feed increased from 43° F. to 59° F., the concentration rate values were corrected to a temperature of 43° F. The correction factor used was 3 percent increase in permeation rate for each degree increase in temperature.

An average percent solids in the membrane bank was calculated from the feed and concentrate solids to determine an operational water removal rate.

TABLE 1.--Maple sap concentration.
Increase in solids as water is lost at 69°F. and 615 p.s.i.

Percent solids			Gallons per square foot of membrane per day		
Feed	Concentration	Average	Observed	Temperature °C.	Corrected
3.3	6.6	4.8	7.9	6	7.9
3.8	7.2	5.5	7.7	7	7.5
4.5	7.9	6.2	7.7	8	7.2
5.2	9.3	7.2	7.9	9	7.2
5.9	10.5	8.2	7.1	10	6.3
7.0	11.7	9.3	7.3	11	6.2
8.3	13.5	10.9	6.9	13	5.5
10.2	16.0	13.1	6.3	14	4.8
13.7	18.3	16.0	5.3	15	3.9

The g.p.s.f.d. figure is the gallons of water removed per square foot of membrane per 24-hour day. This figure is used to determine the number of modules required to perform a particular concentration.

The reduction in "water" rate with increasing solids is typical, due to the increase of effective osmotic pressure of the sirup. The linear function is also typical in this low solids range and tight membranes. Calculations show that in concentrating from 1.5 to 10 percent solids, a water removal rate of 7.3 g.p.s.f.d. would be achieved. In this test, concentrating from 3.3 percent to 14.5 percent, a rate of 6.3 g.p.s.f.d. was obtained. These rates are good but unnecessarily low (percentage of solids in the water) for this application, as can be seen from table 2.

TABLE 2.--Dissolved solids in "sirup" and water

Sirup Percent solids	Water p.p.m.*	Water Percent solids**	Total oxygen demand (p.p.m.)		
			Water	Tank	Concentrate
3.3				72,000	
4.8	8	0.0028	30		68,000
5.5	9				
6.2	11.5				
7.2	14				
8.2	14				
9.3	18	.0009	36	66,000	124,000
10.9	19				
13.1	24	.0009	50	128,000	198,000
16.0	33	.0041	64	170,000	210,000
Tank				176,000	

*Equivalent NaCl conductivity by Myron L TDS meter.
**By evaporation.

In table 2 the initial three columns show the dissolved solids in the product water compared to the average sirup concentration in the modules. Column 2 indicates that the equivalent sodium chloride conductivity increased from 8 p.p.m. at the beginning of the test to 33 p.p.m. at the end of the run. Alone, these figures are not conclusive. The presence of sucrose in a salt solution depresses the electrical conductivity. The depression is increased by increasing amounts of sucrose. In column 3, the results from evaporation of the water samples are shown. Though not too consistent, the water varied from 9 to 41 p.p.m. of solids.

The final set of figures is data taken from an Ionics Model 225 TOD analyzer. This instrument measures total oxygen demand of both inorganic and organic compounds. If we assume that most of the oxygen demand in the tank and concentrate is derived from the sucrose, the TOD of the water represents a reduction of 2,300 to 3,000 times. This is somewhat comparable to the reduction of 4,000 times in the ratio of 16.0 percent solids feed divided by the .004 percent solids in the water.

Figure 3 presents the pH of the concentrate and water with increased concentration. The field-measured pH of the tank and concentrate increased

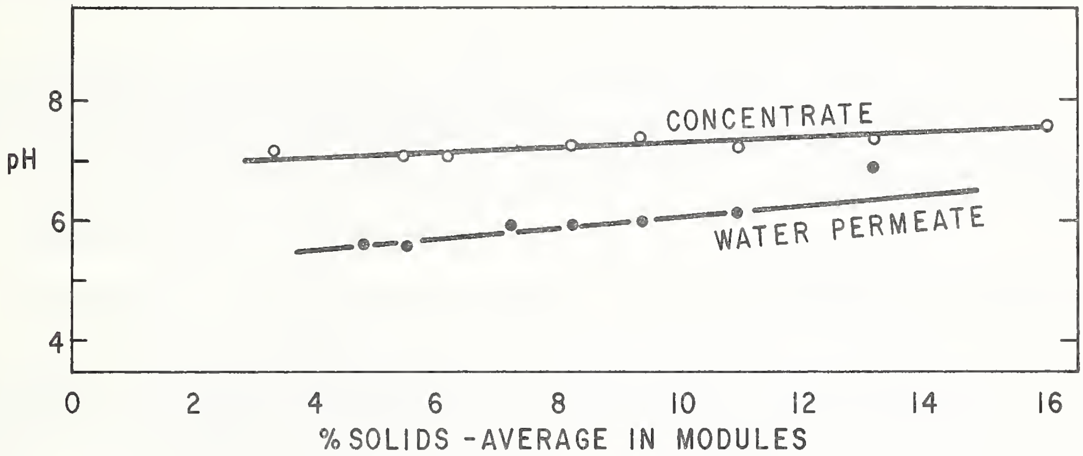

Figure 3.--Change in pH of concentrate and water permeate during concentration of maple sap by reverse osmosis.

from 7.0 to 7.4. Surprisingly enough, the pH of the water started at 5.6 and also increased. The data point for water at 13 percent solids appears out of line and should be rechecked.

Discussion

The reverse osmosis equipment performed without incident during the 7-hour test. The water removed was of high quality. The actual concentration achieved was 14.5 percent, somewhat greater than the original goal of 10 percent. Higher concentrations can be achieved but at increased cost of equipment and operation. For example, the extra square feet of membrane would be as follows:

Concentration From	Concentration To	Square ft. membrane
Percent	Percent	Percent
3	10	100
3	12	105
3	15	113

Power Required

The power required on this run was approximately 10.7 kw.-hr. per 1,000 gallons of feed sap. With power at 0.05/kw.-hr. the cost would be some $0.54 for this run. The use of membranes having lower rejecting capabilities could reduce this cost; however, it is not an important cost factor.

Membrane Selection

If an increase in solids of the water is allowable, say to 0.01 percent, membranes having much higher permeate rates can be utilized. These rates are 50 to 80 percent higher than those shown in table 1. In place of having 95-96 percent sodium chloride rejections, they would have 90-91 percent sodium chloride rejections.

Temperature of Operation

For the purpose of this report, it is assumed that in order to reduce the amount of inversion in the sugars present, an operating temperature of 6° C. is desirable. If the sirup is to go directly to evaporators, this may not be a logical conclusion, and it may be of benefit to permit the solution to increase in temperature.

In a production unit, the time required for concentration would be considerably reduced and would not see the presence of air. That is, the concentrate line would be at the desired percent solids.

To reduce capital costs, it might be desirable to preheat the sap by utilizing some of the steam wasted from the evaporators. For every °C., water rates would increase about 3 percent.

Color in Tank

It was noticeable that the color in the feed tank increased as the concentration increased. This could be the result of increasing temperature (from 6° C. to 15° C.), increasing pH (from 7.0 to 7.4), and dissolving of air in the feed tank with mixing. Presumably, some sugar was inverted.

pH of Water and Sirup

The increase in pH of the product water was from 5.6 to 6.4. The tank increased from 7.0 to 7.4. Apparently, the acidity (possibly carbon dioxide,

which permeates the membrane quite readily) is lost early in the concentration. The rate of pH increase in the product water was approximately twice that of the tank.

The Maple Sirup Producers Manual, Agriculture Handbook No. 134, page 57, paragraph 5, notes that a similar condition exists during evaporation. Evidently this is not detrimental to further processing.

Membrane Replacement

The major operating cost factor of the unit would be the frequency of membrane replacement. Membrane hydrolysis (loss of desalting capability) occurs more rapidly at increased temperatures and pH ranges. The theoretical life at 25° C. and a pH of 5.0 is approximately four years. Since operation is at a temperature of 6° C. and the pH that the membrane sees (product water) is no higher than 6.0, there appears to be good prospects of maximum life.

The membranes produced by Aqua-Chem are readily capable of being replaced in the field. There was no evidence of membrane fouling during or after the run. The present price of a replacement membrane tube is $2.00 per square foot; this can be translated into cost per 1,000 gallons of sirup processed.

The modules must be sanitized after each run and thoroughly cleaned after the season. The modules should be stored with a few parts of chlorine residual to prevent bacterial growth.

Proposed Unit Design

A proposed production unit design is based on the following size criteria:

Feed rate:	10,000 gallons per 16-hour day
Concentration:	2.5 to 10 percent solids
Temperature:	6° C.
Membranes:	90 - 91 percent rejection on NaCl

The 16-hour day was selected as basic, although operation is automatic. The operator would be required to observe pressures every hour or two to ascertain correct operation. With a malfunction, the unit would shut down. The price of a unit this size would be in the $16,000 to $17,000 range. The economics of the use of such equipment must be accomplished by those with more knowledge of the maple sirup supply and market.

REVERSE OSMOSIS IN MINNESOTA

L. V. Alwin
Sugar-Wood-Farm
Mound, Minn.

It is indeed a pleasure to be here this afternoon to meet with all of you, to renew old aquaintances, and to share some of the experiences I've had in Minnesota using some of the latest in commercially available reverse osmosis equipment for extracting water from maple sap prior to cooking.

I would first like to briefly review the maple sugar operation at Sugar-Wood-Farm, describing the reverse osmosis equipment used and its operation, and then comment briefly on the use of reverse osmosis in the sugarbush. As some of you know, my maple sirup operation in Mound is very small, approximately 30 acres of mixed hardwood forest on Lake Minnetonka. The sap gathering is entirely automated, using plastic tubing for sap gathering and automatic pump controls for feeding sap into the cookers. The entire operation is developed for installing and working by one man (myself) each season.

During the inception of the automated sugar farm, the endeavor was to minimize labor, speed up the production of pure maple sirup, and to improve the quality of the product by close control of all processes involved. Sirup production is conducted in a remodeled barn. The setup is a natural for automated plastic tube gathering in that the cookhouse is situated in a natural basin within high-density woods of approximately 40 percent hard maple. All sap is collected through a modified above ground plastic tube system. Lines are tied into one central gathering tank from trees located within a 1,000-ft. radius. The collected sap is pumped from the main gathering tank into the evaporator by a small centrifugal pump. The evaporator operates the pump through the use of electronic liquid level controls.

Several remote gathering tanks are needed to collect and store sap from some of the outlying districts in the sugarbush. Both electric and gasoline operated gear pumps are used to pump remote sap to the central gathering tank. Gear pumps were selected for their capability to pump relatively small quantities of sap at extremely high pressures over very long distances.

The evaporator is specially designed with 1-1/2 times the normal flue heat exchange area to speed evaporation and conserve heat. Both the enclosed hood and fan-ventilated hood exhaust systems are used in different parts of the cooker. Sirup finishing is done in the evaporator and immediately canned while hot.

In the spring of 1971 it was possible to borrow a commercially manufactured reverse osmosis machine for experimenting and gaining experience in applying reverse osmosis for water reduction in sap. Osmonics, Inc., a Minneapolis based firm, provided a 200-gallon-per-day demonstrator unit for this purpose due primarily to the interest and cooperation of Osmonics'

president, Mr. Dean Spatz. A number of these demonstrators had been used previously to extract water from sap, but until this time, there had been no intense use of an R.O. (reverse osmosis) system installed and integrated with other operating equipment on a sugar farm.

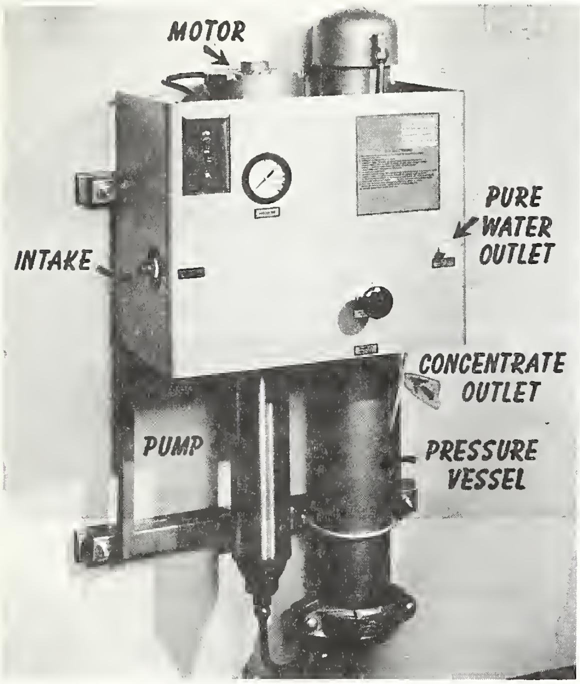

Figure 1.--Osmonics reverse osmosis machine.

The Osmonics #3319 unit (fig. 1) was mounted to a wall inside a room adjoining the sugar house where ample electric power (120 volts, 15 amp.) was available. Hose connections were made from the pump on the central gathering tank to the intake on the Osmonics machine. The Osmonics machine, consisting of a 16-stage centrifugal pump driven by a 3/4-horsepower motor, raised line pressure to approximately 200 p.s.i. inside the pressure vessel. Once the unit was primed it was capable of drawing its own feed from the gathering tank, but since the membrane pressure dropped off considerably, it was necessary to pump the sap from the gathering tank into the R.O. machine at about 15 to 20 pounds pressure.

The first sap introduced into the machine was early in the season, March 28, after a 200-gallon yield from 400 trees. With one pass of sap through the unit, 2 percent sap was increased to nearly 5 percent sap, extracting about 60 percent of the water. The concentrate was pumped into the evaporator and stored until the following sap run. The next sap yield came on March 30, two days later. The sap was again passed through the machine with a resultant 5 percent sugar content.

Up to April 2, approximately 950 gallons of 2 percent sap were reduced to 450 gallons of 5 percent sap using R.O. with no problems whatsoever. The concentrate was cooked down to sirup, then filtered and canned. Quality was commensurate with the sirup of previous years. After April 3, the weather turned cold, below freezing, for several days. During this time the R.O. machine was covered with a blanket and warmed with a 100-watt lamp to prevent any damage to the membrane.

Following the freeze, a much heavier flow of sap was experienced; 600 gallons of sap were collected and again run through the R.O. machine. However, this time the concentrate was recycled back into the gathering tank, remixed, and continually recycled until the concentration in the gathering tank was approximately 6-1/2 percent. This period of concentration took approximately 38 hours using the 200-gallon-per-day machine. The operation was perhaps the equivalent of 2 passes of sap, one at 2 percent and the next at 3-1/2 percent, yielding the final 6-1/2 percent concentrate.

It was quite apparent toward the end of the 38-hour run that the efficiency of the machine was slightly reduced when the sugar concentration rose. In other words, increased sugar concentration resulted in reduced efficiency of the membrane; thus less water could be removed. No bacteria problems were observed at this time. The machine was operating perfectly, as predicted by the manufacturer.

Figure 2 illustrates the sugar concentration process. The initial stage of reduction from about 2 percent sugar to 10 percent sugar requires the removal of a very large amount of water. After reaching 10 percent sugar, the curve shows an inflection toward a higher rate of sugar percent increase per relatively small amount of water removed. The broken line illustrates the rate of water extraction using the OSMO 3319. Due to low pressures, the maximum sugar percentage in sap reached would be 30 percent. It is very apparent here that R.O. would be best used to the left of the inflection point and the cooking process would be best applied to the right of it, or say, after sugar concentration reached 8 to 10 percent sugar. I have also marked on the chart the R.O. sugar concentration per unit number of passes.

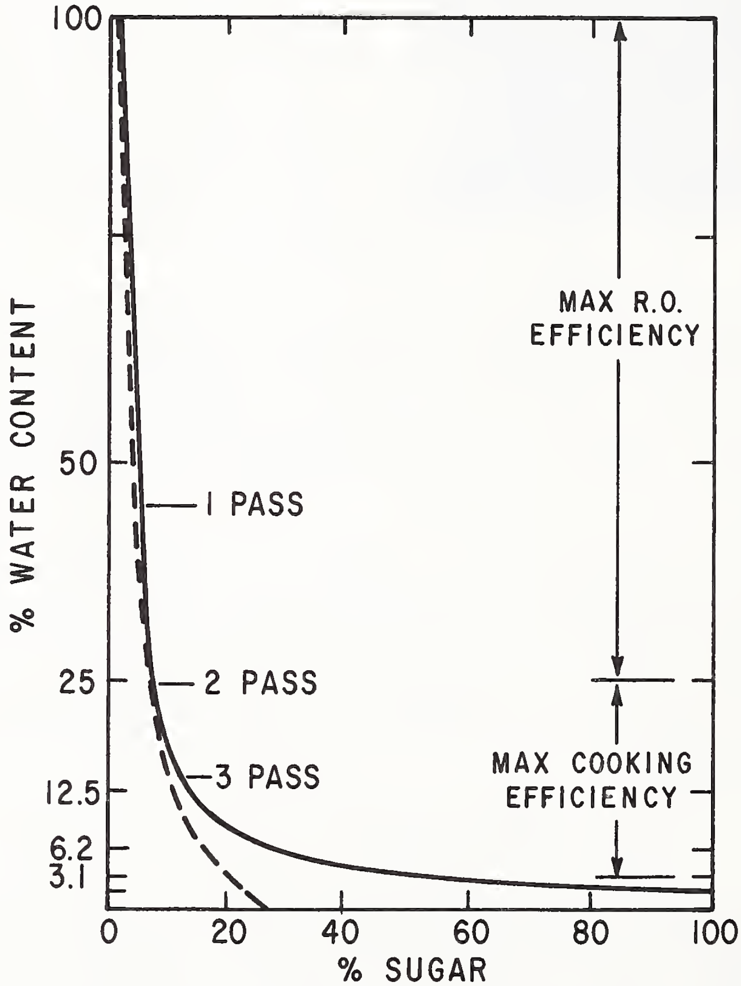

Figure 2.--Reverse osmosis efficiency diagram - 2 percent maple sap with Osmonics #3319 extractor.

It is clear that after 3 passes of increasing concentrate, the use of R.O. becomes very impractical since the time to reduce the water quantity increases rapidly. One should also note that over 50 percent of the water is removed in 1 pass through the R.O. device and 75 percent is removed totally in 2 passes.

Thus, a 1-pass method would require 50 percent of the normal cooking equipment investment, while a 2-pass method, or 75 percent reduction, would require only 25 percent of the normal cooking investment. After the 75 percent reduction of water concentration, to double the sugar concentration would require from 3 to 4 more passes through the R.O. unit, and this would be done at prohibitive cost and time. The cooking process here begins to show marked improvement in efficiency from the inflection point on the graph up to the required 66° Brix. For speed and low cost, it might be more practical to use only 1 pass through R.O., remove 50 to 60 percent of the water, and then cook the rest. This would result in half the fuel cost and half the evaporation time required.

As the sap season progressed to the second week of April, the sap sugar concentration increased from 2 percent to 2-3/4 percent and then later to 3 percent. By April 7, unseasonably warm weather set in, increasing the bacteria in the sap. The effectiveness of the Osmonics machine was drastically reduced; three percent sap was yielding 4 percent after one pass through the unit. The cylinder was back-flushed with some pure extract water which was stored in a 20-gallon drum. The efficiency of the machine was immediately restored, but after several hours of operation, it again returned to the lower efficiency.

An automatic surveillance system with a reversing valve could be installed on this machine to periodically clean the membrane of bacterial growth. Five to ten minutes of back-flushing was all that was required to clean the membrane under mild bacteria growths; however, the nuisance involved of periodically cleaning the unit manually required that it be shut down permanently toward the end of the season. The low sap yield after April 10 and high concentrations of yeast in sap were no match for any filtering equipment. The machine was allowed to stand filled with bacterial sap for approximately one week until the owners retrieved the unit. At this time it was back-flushed with a mild chlorinated water solution. A water rinse prior to the chlorinated rinse revealed a sharp vinegar-tasting solution from the cylinder, but no damage was done to the membrane. Since this time, this Osmonics unit has been operating in many other fields.

Discussion

1. There is a definite place in the maple industry for reverse osmosis machinery. Its application would be twofold in that (a) it saves on fuel regardless of the capital cost (fuel reserves are being depleted rapidly in the world and proportionately increasing in cost as they become depleted; fuel consumed in the evaporation of sap is waste when other equivalent or less expensive methods are available); and (b) labor can be saved when automatic

(unsupervised operation) reduction process is employed and operated unattended on off-hours.

2. No large investment of reverse osmosis equipment should be made by any producer until experience has been gained on a small scale. All operations and processing plants are different and those interested should be sure that the process of reverse osmosis would be of overall economic benefit to their plant. The initial equipment investment, as well as replacement costs of related equipment, is high. Total dependence on R.O. cannot be tolerated if the unit malfunctions due to mechanical breakdown or high bacterial growths. The addition of chemical bacteria killers in sap must be explored. Bacteria growth, a serious problem with R.O., does not exist in the boiling process. The additives must be those which are totally removed through evaporation in the final cooking process.

The investment in R.O. is one which should and could be adapted to other reduction processes required on the farm or to other processing plants in the area which reduce water in products such as milk, cheese whey, candy processing wastes, cider, or sorghum. The more use obtained by the R.O. equipment, the lower the cost will be to the maple portion of the investment.

I am also exploring the possibility of renting R.O. machinery for the 3- to 4-week period in the spring rather than purchasing the unit with all its potential problems. There would be no high capital outlay, larger machines could be used with considerably less investment per unit crop yield, and the machine could be returned unused in the event of a crop failure.

3. Very little technology is required to use R.O. The unit operates as a continuous discharge high pressure filter. Surveillance is only needed to watch the sugar concentration at the discharge end of the cylinder. This can be done using a standard Brix sap hydrometer. If the sap sugar concentrate diminishes below that expected (as shown on the chart), back-flushing or "rinsing" the filter is necessary. (The more flushing, the more down time, and the less effective the machine.) The avilable units are so simple that any normal person could comprehend and operate the process once shown the procedure.

REGIONAL MARKETING PRACTICES[1/]

(Abstract)

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A Maple Marketing Task Force, acting as a subcommittee of the Northeastern Extension Marketing Committee, has been active during the past two years in compiling information on maple marketing methods which are being used successfully by producers and dealers in the Northeast (West Virginia to Maine). Chaired by the writer, the Task Force has also included Edward P. Farrand, extension forester at Pennsylvania State University, University Park, Pa.; Theodore R. Harding, producer-dealer from Athens, Maine; Linwood B. Lesure, producer-dealer from Ashfield, Mass.; Fred C. Webster, extension economist, University of Vermont, Burlington, Vt.; and Fred E. Winch, Jr., extension forester at Cornell University, Ithaca, N. Y. Three meetings have been held and a manuscript prepared which is currently in the hands of the Extension Editor at the University of Vermont. It is expected to be available at cost to all maple States in the near future.

Material included in the Maple Marketing Task Force bulletin includes information on modern containers, new maple products, planning for profits, and marketing techniques.

Under modern containers, the Task Force describes the use of sirup or sugar as banquet favors, warning that small glass containers are hard to obtain, and suggesting that producers use custom packaging by established companies. Plastic containers are described, with suggestions as to filling with the use of a "jig" and a warning that some plastic will not hold up when packed with hot sirup; also, the sirup will not maintain good flavor when allowed to stand in these containers for long periods. Earthenware containers are described, and the use of unusual containers and clever labels is suggested to increase sales.

Under new maple products, the preparation and sale of maple cotton candy, with a potential net return per gallon of sirup of $13.84, is described. Maple Crunchies (coated popcorn) is mentioned as an outlet for Grade B and C sirup. Daily sales of fresh sugar are recommended as a way to double the return from wholesale sirup in cans. Maple peanut brittle or walnut brittle, which has an expanding market needing capital, can also be made with Grade B sirup. Maple crumb sugar can be made by heating sirup to high temperatures, and can be sold at a good profit.

Planning for profits includes improving production and packaging methods, using a pricing schedule that covers all costs and leaves a margin for profit, and achieving greater profits by using new channels of distribution.

1/Presented by E. Farrand, Extension Forester, Pennsylvania State University.

Crystal coating is recommended when selling sugar candy, and group marketing is suggested for obtaining capital and holding sirup for periods of peak prices.

Desirable marketing techniques described are sales to roadside stands, sales to grocery stores, promotion through sugar-on-snow, promotion at ski and other recreation areas, sales to restaurants, diversity in products and packages, and advertising. Maple movies, which are available from extension foresters in several States, are suggested as tools to use in developing a greater knowledge of and desire for maple products. A maple slide talk (80 slides) has been prepared which should soon be available for sale at cost from the Extension Editor, Morrill Hall, University of Vermont, Burlington, Vt. 05401.

MODERNIZING MAPLE MARKETING IN LEWIS COUNTY, N. Y.

Cornelius F. Handy and Fred E. Winch, Jr.
Cornell University
Ithaca, N. Y.

Lewis County is a rural county situated on the western fringe of the Adirondacks in northern New York. Typically the county has depended on its resources from the forests and from adequate rainfall for the production of food and fiber as the mainstay of its population. We have forest products industries in pulp and paper and timber production. Our soil resources are varied. East of the Black River we have extensive areas of a very sandy Adirondack outwash soil which grows fine maple, good cherry, and excellent conifers, but is not well suited to our intensive agriculture. On the western side of the county and especially in the river valley, we have a limestone soil, fertile and well watered, which supports a growing and intensive dairy industry. Outside of forest products, dairy and its complementary agri-business make up the greater part of the industrial base of the county.

Of late, with a growing and improving road system, recreation is becoming a large user of land in both the Adirondack outwash and the Tug Hill plateau in the western part of the county. This has been bringing larger numbers of people to the county in recent years.

Lewis County also has a human resource quite different from most comparable areas of the State. Many of the inhabitants of the county are of German Mennonite stock, a thrifty, hard-working group used to outside labor in fields and forest and traditionally utilizing, with high husbandry skills, the resources at hand.

Maple Production Has Been Traditional

If we look at the history of Lewis County, we see that maple has been a traditional crop. To the south, Boonville (just over the county line) was settled by sugar makers from the Holland Land Company. Boonville was named for an "imported" sugar maker who established large evaporators to make sugar for the northern trade in early 1800. The Louisiana Purchase "killed" the large scale industry but sugar making continued. In the twenties, 75 to 80 percent of the farms in the county produced maple products for home use and for drum sales. At the higher elevations of Tug Hill and on the heavy clay soils of the surrounding area much of the sirup was made for home use and barter (exchange at the store for other products) even into the late 20's. The common product was, as has been the case in other areas, block sugar though some sirup was placed in the trade.

As was true in other parts of New York, the number of farms started to decline in the midtwenties. This trend has continued. Though sugarbushes were cut before farms were sold (many were purchased for State reforestation areas), this was not a serious factor in the production picture.

Markets of the Recent Past

Though farms continued to decline in numbers, shifts in production were noticeable. In the late 40's and throughout the 50's,maple continued to be a good cash income crop on practically all the farms in maple areas. However, those farms on better soil types began to shift into larger dairy herds and to de-emphasize maple. On the light soil areas, maple held its own and to some extent increased with consequent increase in production.

It is interesting to note that as forest products played larger roles in the towns east of the river, maple too began to be of more importance. Several loggers and large forest landowners began to tap more trees and produce more sirup. Logging crews played a large role in this type of operation. Several such crews went into the woods where "sugar camps" were set up and stayed in the woods for the season. Many operators tapped and hung 8,000 to more than 12,000 buckets. Such operations have always taken pride in the quality of sirup produced, with many camps swearing they never produced anything less than a fancy grade sirup. Over 95 percent of all such production went into bulk sales and was shipped out of the State, usually to Vermont, though some from the county continued to be packaged in Lowville.

Up till the 1950's, the major part of the county production was sold this way. Roads and access to the county by the general public was very much limited compared to the present. As a result, 85-90 percent of the total production was sold into the bulk market even though the area had developed a reputation for a high-quality product. Very few producers sold appreciable amounts of their total production retail and what was sold was in gallon tins with little attention to labels or attractive containers.

The Enterprise Changes

Change since 1960 is reflected in both the production and marketing areas. Some of these changes in production are related to outside forces as well as farm location. Of direct bearing on the maple enterprise has been the increase in size of the dairy herds on the farms located on a good soil resource. Another influence on the enterprise is that of the new technology, as new equipment developed for sugaring requires the investment of capital. This raises the question: Will an investment in new maple equipment pay off? The trend is therefore indicated--farms on good soils have grown in size and have deemphasized maple. As a result, only 10-15 percent of the farms in the county now produce maple sirup, and less than 50 percent of the maple producers are full-time commercial farmers. An entirely new group of producers with new attitudes have developed. Maple producers are now tradesmen, factory workers, artisans, and forest workers.

Thus maple producers in Lewis County are confronted with two major management questions. First, does the maple enterprise pay, and second, what might they do to increase the returns from this enterprise? Some cooperators in the Lewis County Farm Business Management Project decided to study the maple enterprise in 1968. The project was continued for three years with 14 maple producers submitting enterprise records which provided the basis for all producers to study strengths and weaknesses of their maple enterprise. Now that producers have access to these records, they are using this information to make management decisions. Some producers are giving up the production of sirup and others are expanding in order to improve their efficiency.

The 1970 summary of the cost account study shows that in that year (not the best as far as production goes) the average of 14 farms produced 660 gallons per farm to gross an average of $3,416. Production ranged from 180 to 2,700 gallons. The average value of a gallon of sirup sold in drums was $3.61; in retail packages it was $5.36, while the range in value was from $3.90 to $7.61. Of the 14 farms, 8 sold sirup in drums.

Other figures of interest from the study are:

.27	gallon of sirup per tap
1.09	gallons of sirup per hour of labor
$1.92	invested per tap
$5.18	gross income per gallon of sirup

These figures are out of date as the 1971 prices are much higher.

Looking at the summaries over the years, the average number of taps per farm has increased; investment in equipment has increased; operator labor has decreased slightly; gallons of sirup produced has increased appreciably, as has production per tap; labor efficiency has increased; and profit in the enterprise and return on the operators' labor has shown good response.

Steps in the New Marketing

The first really big step in marketing was brought about by a better access to the county through an expanding highway system. Retail sales, beginning as a small part of the total production, began to grow. Better labeling and the realization that the size of the container must be reduced plus the fact that a year-round supply of sirup was needed enabled this county to upgrade its retail sales. Along with this sale of liquid sirup came the sale of other products. Maple cream was a "new" product which caught on relatively early. Molded and coated sugars followed shortly.

These changes were brought about by active programs of the Cooperative Extension Service and its personnel, local and State. With the income generated by sirup, it was worthwhile for Extension to put a reasonable number of man-days into an annual program for the producers. Dr. C. O. Willits and his research staff from the Philadelphia laboratory helped to emphasize production of products other than sirup through schools held in the county.

A great deal of attention was given to standardizing sirup for retail sales through better instrumentation. Emphasis was placed on individual marketing opportunities and problems. As a result, through concerted action, many producers are placing all table quality sirup on the market and many are buying bulk to keep the market growing even though a lot of producers have quadrupled their production.

A new attitude on the part of producers developed. Many nonfarm producers became aware that prices for bulk sirup was not keeping pace with costs. As a result, there was a general realization that quantity bulk production that had been enough to give the buyers a security of supply in the past might just enable producers to exert a little leverage. Some began to hold back production and not sell during the usual bulk sales season. This netted better prices of 2 to 3 cents per pound in those early attempts at market influencing.

In the early fifties, a northern New York maple producers association was formed to take in all the northern counties. This never became really active, and few producers in Lewis County stuck with the group. There had been unfortunate experiences with a co-op in the past in the area. Members previously had joined the co-op in the hope of getting high prices for low-grade sirup. Markets such as local retail outlets and good bulk prices in Vermont kept the high grades of sirup out of the co-op and it folded. As a result, "outside" organizations were not favored.

The local Extension organization then brought groups of producers together to discuss market problems and opportunities. Short crops in the Midwest at this time caused buyers from there to come into Lewis County seeking sirup. Prices for all grades were better from these markets than from traditional areas. Less-than-normal crops downstate also brought in buyers.

Following these events and the increasing demands for Lewis County sirup, a committee chaired by Gordon Brookman with Philip Gravink from Chautauqua County, the second largest producing county; Howard Virkler and Gilbert Lehman of Lewis County; and the two authors, and two representatives of the New York Farm Bureau commodity marketing group met to discuss maple marketing problems. As a result of the meeting on November 1, 1965, a State maple marketing program of the Farm Bureau was formed to seek wider markets, to keep the membership informed of the price trends and sirup needs, to inform the industry's buyers of producers' costs, and to seek prices sufficient to give a reasonable profit. A growing membership was developed in Lewis County.

At the same time, a crop loan program under the Agricultural Stabilization and Conservation Service aegis was proposed in Lewis County and with educational work by Cooperative Extension, it was carried from there to the other principal producing areas. This program appeared promising and it was timely; however, it never got underway as at that time ASCS programs were not being expanded to take in new commodities. It did serve a useful purpose in getting producers to face up to some of the marketing needs of the industry.

A third program followed, the establishment of a viable Lewis County

Maple Producers Association which worked to promote Lewis County maple sirup and to coordinate some of the marketing opportunities in the county. This close-knit organization working in cooperation with Cooperative Extension, the Farm Bureau, the local Chamber of Commerce, and other groups has promoted maple in many ways, for example, by a local "Queen" contest in the spring, a booth at the County Fair in midsummer, and by other community events.

As a result of the foregoing activities, there has been a decided improvement in the marketing procedures in the county:

1. Retail outlets have grown in numbers and volume. Prices have increased to keep up with the inflationary trends and new products have been added to upgrade the labor income of these family operated enterprises.

2. Size of the enterprise has increased with the addition of more taps, more updated equipment, and more modern sales techniques while holding the quality level to the traditional Lewis County standard.

3. Recognition of the industry's place in the county by the Chamber of Commerce and similar organizations.

4. Bulk sales are bringing better prices due to coordinated marketing procedures, to better information on maple production and supply, and to the maintenance of quality.

5. Development of a new producer group made of those who are not directly connected with other phases of agriculture.

REVIEW OF MAPLE SIRUP GRADING LAWS

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In reviewing the grading laws of the States that have standards for grading maple sirup, I found they were fundamentally quite similar. The differences lie mostly in the names of the grades and the density requirements, especially in the way the density is expressed.

All States use the same color standards as established by the U. S. Department of Agriculture. The three colors used are called "Light Amber," "Medium Amber," and "Dark Amber."

Purity requirements of all States specify that maple sirup shall consist only of sirup made by the concentration of pure maple sap and shall contain no adulterant. The clarity of the sirup varied slightly between States. Some required it to be clear, or at least some grades be clear or reasonably so, but in no case was it allowed to be cloudier than the cloudy standard as represented by the standards of the U. S. Department of Agriculture.

The flavor requirements among the States were basically the same with variations in the way they were explained. For example, Vermont law states that Fancy sirup "shall have a delicately sweet original maple flavor characteristic of Fancy grade and shall not be or show evidence of having been damaged by any means." Maine says the same with the addition, "it shall not be sharp or bitter or buddy or taste of any off flavor." New Hampshire and New York both state, "it shall possess a characteristic maple flavor free from damage caused by scorching, buddiness, or any other objectionable flavor or odor." What they are all trying to say, in lieu of a better explanation, is Fancy sirup should taste like Fancy sirup.

Four States--Vermont, Maine, New York, and New Hampshire--make it compulsory to grade all sirup sold retail. Wisconsin has a bill in its legislature which, if and when it is passed, will bring the standards of their grades up to the same requirements of other States but will not be compulsory. The other maple producing States have laws which only control the purity and adulteration of maple sirup.

Some State's regulations contain a clause stating that only sirup produced within that State may bear that State's name in connection with the grade. Since this regulation is more frequently violated than any other regulation and since the source of the product has little, if any, bearing on the quality of the product, it would appear that the regulation is superfluous and should be stricken from the rules and regulations.

The density requirements are set forth in the following table. While

the minimum density required by the U. S. Department of Agriculture is now 65.46° Brix @ 68° F. or 35.27° Baume @ 68° F., a change is pending to increase the density to 66.0° Brix @ 68° F. to conform to the recommendation of the National Maple Syrup Council (NMSC).

TABLE 1.--Density requirements

Designating agency	Brix	Baume (Be)	Weight
USDA (old)	65.46° @ 68° F.	35.27° @ 68° F.	11 lb./gal.
USDA (pending)	66.0° @ 68° F.		
Vt.		36° @ 60° F.	
Me.		36° @ 60° F.	
N. Y.	66.0° @ 68° F.		
N. H.	67° @ 68° F.	36° @ 60° F.	
Wis. (old)			11 lb./gal
Wis. (new)	66.0° @ 68° F.		

Note: 67° Brix @ 68° F. = 35.9° Be @ 68° F. or 36.1° Be @ 60° F.
66° Brix @ 68° F. = 35.4° Be @ 68° F. or 35.6° Be @ 60° F.

The names of the grades show more variation than any other specification (see table 2). Most of the States use the U. S. terms "Grade AA or Fancy," Grade A," "Grade B," and "Grade C, Commercial or Unclassified." New York recommends using the "Light Amber Table Grade," "Medium Amber Table Grade," and "Dark Amber Table Grade" terminology as recommended several years ago by the National Maple Syrup Council, but allows use of the U. S. terms if desired. New Hampshire requires the U. S. terms but allows the Light Amber, Medium Amber, Dark Amber terms to be added if desired. Wisconsin's present standards use the U. S. Grade terms but are one grade lower. Their proposed standards will raise these grades to conform with the U. S. and other State's standards. Vermont, New Hampshire, and Maine all use the U. S. Grade names with one exception--Maine substituted the term "Dark Grade" for Grade B.

Conclusion

The National Maple Syrup Council spent much time and effort developing a guide for sirup grading standards that was simple and logical. The recommendation of the Council included only the change in density and grade names. The U.S. Bureau of Standards, while it indicates approval of these recommendations, has been slow to adopt them. Most of the States that recently passed grading laws have not adopted this guide and there is still confusion among the consumers and problems for packers selling in States other than their own.

TABLE 2.--Designations of maple sirup grade by color

Designating agency	USDA standard color			
	LIGHT (Light Amber or lighter)	MEDIUM (From darker than Light Amber to Medium Amber)	DARK (From darker than Medium Amber to Dark Amber)	VERY DARK (Darker than Dark Amber)
USDA	Grade AA (Fancy)	Grade A	Grade B	Unclassified
National Maple Syrup Council	Light Amber or Fancy	Medium Amber or Grade A	Dark Amber or Utility	Very Dark Amber or Commercial
Vermont	Fancy Grade	Grade A	Grade B	Grade C for Proc-essing
Maine	Fancy Grade	Grade A	Dark Grade	Processing Grade
New York (optional)	Light Amber or Grade AA	Medium Amber or Grade A	Dark Amber or Grade B	--
New Hampshire	Fancy	Grade A	Grade B	Grade C
Wisconsin:				
Old	Fancy		Grade A	Manufacturer's
New	Fancy	Grade A	Utility	Commercial

MAPLE SIRUP IN OREGON

(Abstract)

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An exploratory study was undertaken to evaluate sap flow characteristics of bigleaf maple (Acer macrophyllum) and the quality of bigleaf maple sirup. Fifteen tapholes were drilled November 17, 1970, about 2 weeks after leaf fall. Paraformaldehyde pellets and sap bags were used. Sap flowed almost immediately, increased in December, then tapered off rapidly in late January in spite of continuing good sugar weather. The original tapholes were abandoned and a new taphole drilled near the old one in all but two of the trees. The new tapholes produced well during February and intermittently through early March, stopping by the time of bud bursting, about March 23. Average of the combined flow from each original taphole plus its replacement was 6.9 gallons. Three pairs produced over 14 gallons of sap each. Sap sweetness varied among individual tapholes from 1.0° to 2.6° Brix, but average sap sweetness was low. Sweetness varied with the season from about 0.8° Brix in early December, to 1.4° in late January and early February, and back down to 0.8° in early March.

Bigleaf maple sap was concentrated into sirup in steam kettles; then sirup samples were sent to the ARS laboratory at Philadelphia for analysis. Sirup quality was evaluated using the same procedures as for commercial sugar maple sirup. Presence of typical maple flavor ranged from fair to poor. Ash percent averaged 3.3, pH 6.3, conductivity 630, percent invert sugar 0.32, and color grade B.

We conclude that sirup production from bigleaf maple offers definite possibilities. Further trials are recommended on a hobby basis, but we should not rule out the possibility of commercial production as more local experience is gained. The early and late season periods of low sap flows, and very low sugar content can be avoided. Trees with high sugar content and high sap flow can be selected. Use of commercial evaporators rather than steam kettles should improve flavor. The many techniques for increasing production and improving flavor developed through years of experience with sugar maple should be tried with the Western bigleaf maple before a final evaluation of its sirup production potential is made.

THE NATIONAL PURE MAPLE SIRUP CONSUMER SURVEY

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The Need for Marketing Research

The USDA Forest Service's maple products marketing project in Burlington, Vt., has as its mission the improvement of economic opportunities in rural America. With an adequate maple resource base, there is an opportunity for expansion of the sugar maple industry. However, expansion of this industry depends on the development of new markets and on increased efficiencies in marketing and production.

Information about consumer use and purchasing patterns for maple sirup is basic to any recommendation for increasing marketing efficiency and opening new markets. In reviewing the literature concerning maple marketing, two conclusions emerge. Information about consumer use, preferences, and purchasing patterns for pure maple sirup is limited. From the existing shreds of evidence, it appears that maple producers are not efficiently marketing their products to satisfy consumer preferences and maximize producer profit.

With these thoughts in mind, a national survey of maple consumers was conducted. The objectives of the study were to identify consumer preferences and consumer purchasing patterns for maple sirup products. By conducting a national study, we were able to isolate consumer differences for different regions, such as the South and the Northeast.

To accomplish the objectives, a telephone survey technique was adopted, using a standard questionnaire. Since we wanted responses only from maple users, nonusers were dropped from the interview as soon as they were identified. The telephone interview technique was the most efficient method of screening the general population for the relatively few people who use pure maple sirup.

The questionnaire contained 16 multipart questions, including a detailed screening procedure to make certain only pure maple sirup users would be included in the study. The interview required about 18 minutes to administer. About 1,400 interviews were conducted; 1,200 are included in this analysis.

A survey of this size and scope generates a large amount of data. This discussion will be limited to differences in maple preference and use between the Midwest and Northeast area and the Southeast, South, and West area. Five different sections of the questionnaire will be used to illustrate these

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1/Presented by Lawrence D. Garrett, Project Leader, Northeastern Forest Experiment Station, Forest Service, USDA, Burlington, Vt.

differences: screening for maple use, maple purchasing patterns, maple use patterns, preference for maple products, and preference for maple packaging.

Screening for Maple Use

The United States was divided into five regions for analysis--the Northeast, Southeast, South, Midwest, and West. Within each region three sampling points were randomly selected--a metropolitan area with a population of 1 million or more, a metropolitan area with a population of 500 thousand to 1 million, and a small city with a population of less than 500 thousand.

The following points are listed in order from the largest to smallest in size within each region. The regions are noted in figure 1. In the Northeast the sample points were Buffalo, N. Y.; Manchester, N. H.; and Billerica, Mass. In the Southeast they were Atlanta, Ga.; Wilmington, Del.; and Gastonia, N. C. In the South they were Houston, Tex.; Shreveport, La.; and Oakridge, Tenn. In the Midwest they were Chicago, Ill.; Omaha, Nebr.; and Kingston, Mich.; and in the West, Seattle, Wash.; Bakersfield, Calif.; and Greeley, Colo.

Maple sirup has become a generic name throughout much of the country and may be used to refer to maple flavored sirups, or even pancake sirups without maple flavoring. The screening process insured that only people who used pure maple sirup in the past 12 months were included in the study. The study revealed that only 9 percent of the United States population used maple sirup in this time period.

Regionally there were about 8 million users in the Northeast, 1 1/2 million in the Southeast, 1/2 million in the South, almost 6 million in the Midwest, and 2 million in the West. The highest percentage of the population using maple, 16.8 percent, occurred in the Northeast. The lowest percentage, 1.6 percent, occurred in the South (figure 1).

It is significant that over half of the U. S. population lives in or near the commercial maple producing area in the Northeast and Midwest. However, only about 14 percent of these people used pure maple sirup during the past 12 months. This is an indication that there is room for market expansion within the maple producing areas alone.

A quick appraisal of the data indicates that significant differences in responses occurred between the maple producing regions and the other regions. The implication of these results is that different marketing strategies and techniques will probably be necessary in the different regions.

Maple Purchasing and Use Patterns

The sources, or retail outlets, for maple are an important consideration in setting marketing strategy. As expected, there were significant differences in types of retail outlets between areas. The roadside stand, farmer's house, or sugarhouse is still the traditional source of maple in the maple producing area. The retail sale is made at or very near the point

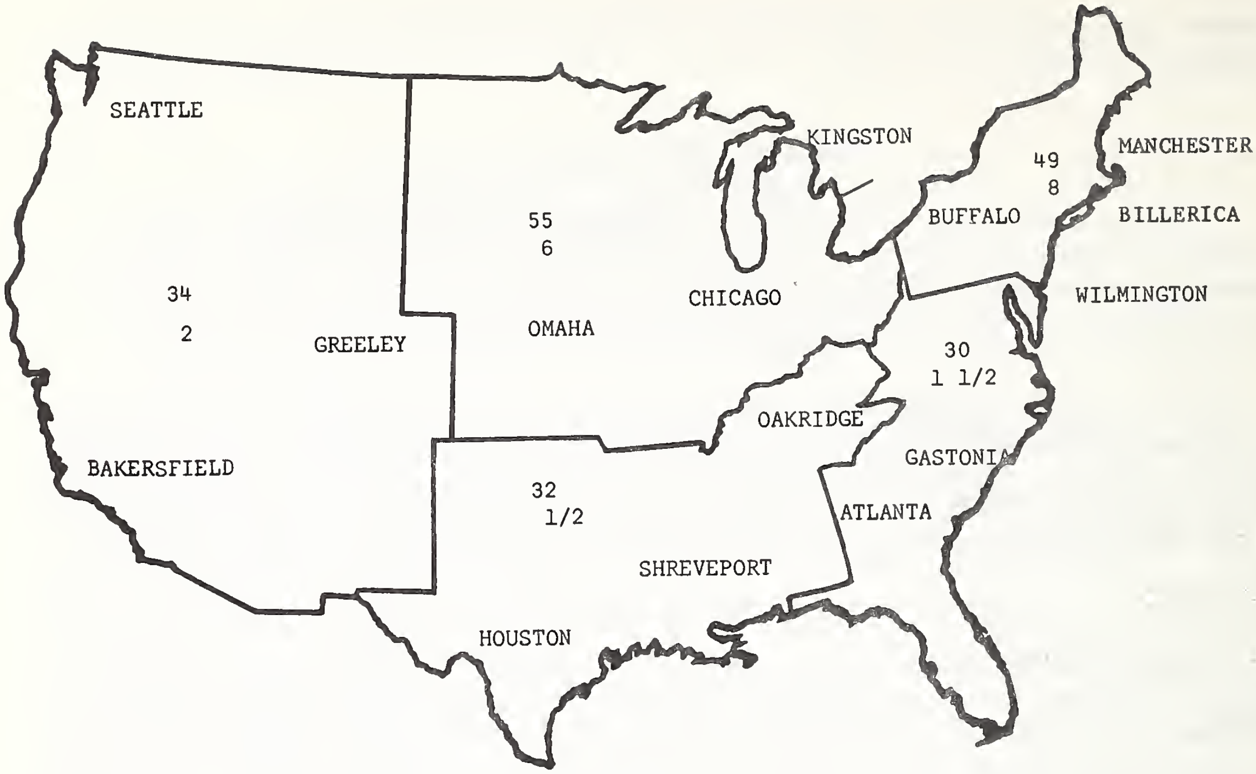

Figure 1.--Study regions and sample cities showing total population in millions within regions and estimated maple-using population in millions.

of production. Sixty-seven percent of the respondents in the maple producing area indicated this source. This source is of no importance outside of the maple producing area. Those respondents indicating a purchase at this source could very well have done so on a trip to the Northeast or Midwest.

In the area not in maple production the regular retail grocery store and supermarket supplied maple to 73 percent of the respondents. This compares to 26 percent of the respondents in the maple producing areas. These two categories--(1) roadside stand, farmer's house, and sugar house, and (2) regular retail grocery store and supermarket--account for about 90 percent of the retail sales of pure maple sirup (table 1).

The survey also indicates that people who purchase maple from regular retail grocery stores and supermarkets on the average purchased maple about twice as frequently as those who purchased from roadside stands, farmer's house, or sugar houses. People who purchased from other sources made about one purchase a year from these sources.

Maple use patterns also differ significantly between the two areas. To begin with, maple sirup is used much more consistently the year round in the maple production area than in the remaining area. Two-thirds to over three-fourths of the respondents used maple at least once during every season of the year in the maple producing area. In the remaining area, maple was used at least once by over four-fifths of the respondents during the winter and by only two-fifths of the respondents during the summer. Maple use in the

nonmaple producing area seems to be associated positively with colder weather in fall and winter (table 2).

TABLE 1.--Retail sources of pure maple sirup

Source	Purchased maple at least once in past 12 months	
	Maple producing area	Remaining area
	Percent	Percent
Regular retail store & supermarket	26	73
Specialty food shop, health food store, or delicatessen	4	11
Roadside stand, farmer's house, or sugar house	67	10
Gift shop	8	4
Mail order company	--	2
Other	6	7
No answer	1	1
Basis: Number who purchase pure maple sirup	480	328

Maple purchases in the maple producing area are associated with maple production; two-thirds of the respondents made sirup purchases in the spring. In the remaining area, sirup purchases are associated with use of the product where both purchases and use are highest in the fall and winter and low in the spring and summer.

TABLE 2.--Association between maple use and purchase by season of the year

	Purchased maple at least once		Used maple at least once	
	Maple producing area	Remaining area	Maple producing area	Remaining area
	Percent	Percent	Percent	Percent
Summer	26	41	64	43
Fall	38	57	70	64
Winter	21	67	79	84
Spring	65	39	72	45

Although maple has been referred to as a gourmet food item, there is evidence that it is not sold that way by grocery retailers. Over 80 percent of the respondents who purchased maple from regular retail grocery stores and supermarkets find it in the same shelf area with other sirups.

The use of maple sirup on pancakes is the predominate use. About 94 percent of the respondents used maple on pancakes. Sirup on waffles and French toast, although less popular than pancakes, was indicated by 59 percent and 53 percent of the respondents, respectively. Minor uses for maple such as cooking, baking, and candymaking were indicated by only 31 percent of the respondents (table 3).

TABLE 3.--Foods on which pure maple sirup is used or served

Item	Percentage of respondents indicating use	
	Maple producing area	Remaining area
Pancakes	95	93
Waffles	56	63
French toast	61	42
Ice cream	30	12
Other	31	31
No answer	.1	.1

We are also interested in buyer satisfaction with the product. Only 7 percent of the respondents felt that they would not buy pure maple sirup again. The reasons given for not purchasing the product were numerous. The most frequently mentioned reason for not purchasing again is that they felt the price was too high. Satisfaction with the product itself appears to be very high.

Preference for Maple Products

About one-fifth of the respondents indicated that they used only maple sirup in the past 12 months and no other sirups or toppings. A rather high percentage, 62 percent, said that they also used maple and cane sirup blends (table 4).

About 43 percent of the respondents who used cane and maple blends said that they used blends more frequently than they used pure maple. This result did not vary between regions (table 5).

Finally, respondents were asked the importance of using pure maple in cane and maple blends. More than half felt that it was very important.

From this series of questions it would appear that an old-fashioned maple blend containing a high percentage of pure maple, say 25 percent, would find a market. People like the flavor of maple. A high percentage of those that use pure maple also use maple blends, currently containing about 5 percent pure maple. There is a trade-off between what one would prefer to eat and what he would prefer to pay for.

TABLE 4.--Sirups and toppings used for the same purpose as pure maple sirup in the past 12 months

Sirups and toppings	Maple producing area	Remaining area
	Percent	Percent
Molasses	13	22
Honey	33	51
Maple flavored sirup	60	64
Other sirups containing no maple flavor or sirup	20	36
None of these	24	17
Basis: Total number of respondents	736	451

TABLE 5.--Use of maple flavored sirup (cane or corn sirup with maple flavoring) compared to use of pure maple sirup

	Maple producing area	Remaining area
	Percent	Percent
More than	43	45
Used about as often	27	25
Less than	28	30
Don't know/no answer	3	--
Basis: Number who used maple-flavored sirup	442	288

Preference for Maple Packaging

The type of maple container most often purchased in the maple producing area is metal, followed by glass. The type of maple container most often purchased in the area not in maple production is glass, followed by metal. Very little sirup is purchased in plastic because very little sirup is put in plastic containers (table 6).

When asked for their preference for a container, the percentage of respondents preferring metal was half the number now purchasing maple in metal. Twenty-three percent of all the respondents preferred a plastic container. More respondents in the maple producing area said that they preferred glass than now buy sirup in glass. The reverse was true in the remaining area (table 6).

TABLE 6.--Type of maple-sirup container purchased and preferred in maple producing areas and other areas (percent)

Container	Maple producing area (Total respondents: 736)		Remaining area (Total respondents: 451)	
	Purchased	Preferred	Purchased	Preferred
Metal	55	24	30	15
Plastic	4	23	4	23
Glass	40	48	65	58
Other	1	1	1	1
No answer	0.4	4	0.4	3

Three-fourths to four-fifths of the respondents said they would like to see the color of the sirup through the container. This implies either a glass or a transparent or translucent plastic container. The number of people who wouldn't care to see the sirup through the container was about equal to the number of people who preferred metal cans. We hope that these were the same people!

The study generated much more information than could possibly be presented in this short article. What has been shown are the most conspicuous results, the kind that are obvious with a few perusals of the data. The information will be much more closely scrutinized and analyzed through statistical techniques to bring out even subtle associations in the data. The intent is to develop a series of marketing strategies based on this data. The strategies will be stated in the form of hypotheses to be subjected to statistical testing through actual in-store selling experiments and in-home testing.

MAPLE INDUSTRY POTENTIAL IN WEST VIRGINIA

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Perspective

Potential is defined as having the capacity for existence. A definition of potential suggests measurability to some degree or magnitude, based upon known facts specific to the subject.

It would seem that a study to describe the potential of the maple sirup industry in West Virginia might at best be called "busy work" since it is a known fact that sugar maple is abundant in the Mountain State. One estimate places total volume at 1,450,000 board-feet. This in turn provides an estimate of 19,000,000 taps. The potential when viewed in this manner is seemingly very high and over the years, statements to that effect have been made. However, there are at least two factors that have not been considered by those who would make such judgments. The first relates to density, that is, in many areas of West Virginia where sugar maple occurs, density is not sufficient to support an industry, even though volume may be high. Second, the demand for the "production" of multiple goods and services from the one basic raw material suggests that all the maple trees in the State would not be available for sap production. When these two points are considered, the total supply available to the maple sirup industry becomes something less than the total physical supply. These two factors then present the first two qualifying statements to any definition of the magnitude of potential. The first fences have been built, so to speak.

In addition to density and economic supply, there are certain social and economic forces at work which will further restrict or enhance the magnitude of the potential. For example, one might ask the question, "Why, if indeed the potential is high, are there not more individuals involved, and why is not output greater than the estimated 10,000 gallons of sirup per year?" It is not the purpose of this study to examine these questions; rather, from previous knowledge, it was determined that the potential for development as a "home industry" was rather low. It was assumed that if any potential did exist, it was in the development of the industry around the central evaporator.

The objective of this study, therefore, was to describe locations with both a raw material and a market orientation, where central evaporators might have a reasonable chance for success. What follows then is a discussion of the current study in West Virginia with an analysis based upon data collected to date.

Raw Material

As a beginning base of information, the Forest Survey of 1964 (Timber Resources of West Virginia, U. S. Forest Service Resource Bulletin, NE-2) was examined. Calculations were made to determine the potential output of sirup, assuming all trees were available for sap production. The decision was made to limit the survey to those counties having a potential of 100,000 gallons of sirup or more per year. Then, through discussions with foresters and others who were familiar with the selected counties, further refinement in the number of counties to be examined resulted, based upon their judgment that density was not sufficient to justify the establishment of a central evaporator. Finally, eleven counties were selected, with a potential of approximately 7,000,000 taps.

As suggested previously, sugar maple is in demand as raw material for multiple goods and services. It is in demand by the wood-based industries, by the recreation industry, and by those owners who just want to see it growing. The question becomes, "What part of the volume represented by the 7,000,000 taps is actually available for sap production?"

We decided to go directly to the owners of the trees. In order to define this population, the County Extension Agent in each county selected called a meeting of those individuals in his county whom he believed to have a good knowledge of the location and ownership of stands of sugar maple. These were placed upon a county map to facilitate subsequent location by the interviewer. The interviewer was employed and trained to elicit proper answers to the questions asked and to take sample data in the stands in order to facilitate the estimate of number of taps by diameter class. It was required at the onset that the person would be well known and trusted in the county. Try to meet this restriction on $1.65 per hour!

In addition, it was necessary to define the population of maple stands and their distribution on public lands since this class of landownership is so important. The Monongahela National Forest occupies almost one million acres, and two additional public ownerships--the Kumbrabow State Forest and Holly River State Park--occupy an additional 10 to 15,000 acres. At my request, district rangers on the Monongahela initiated the survey. The Forest Supervisor and Park Supervisor initiated the survey on properties under their supervision. As a consequence, all identifiable sugar stands, consisting of both private and public holdings, were included in the survey. As a matter of course, many stands were not located. It is felt, however, that the stands identified are in the majority and are sufficient to attach some relative degree of potential for the area represented.

Results to date indicate 25,000 taps distributed among 17 private landowners in Preston County; 24,000 taps among 46 private landowners in Grant County; 50,000 taps among 13 landowners in Tucker County, 7,000 private and 43,000 public; 15,000 plus taps in the lower corner of Garrett County, Md.;

10,000 taps among 25 private landowners in Pendleton County; and 13,000 taps among 27 private landowners in Barbour County. Randolph, Pocahontas, Webster, and Nicholas Counties are not yet completed, but one landowner in Randolph has reported in excess of 30,000 taps with at least that many more. In addition, the State Forest is located in Randolph with the State Park nearby. The State Forest and State Park are located at a considerable distance from the National Forest. Also, there are several large landholders in this area.

With the exception of Grant and Pendleton Counties, most of the trees occur in forest stands.

Most of the taps are available only under a lease arrangement, and very few individuals interviewed expressed an interest in producing sap.

The survey data will allow limited profile development of the owners of the sap supply.

Market Orientation

In the collection of data with regard to markets, a retail market is assumed since the highest marginal returns occur in this practice. Product exposure would appear to be quite high. The maple country of West Virginia is highly accessible. Timewise from the major population centers, it is located at a maximum of 2.5 to 3.0 hours away. Recreational facilities are improving and expanding in numbers, with huge investments being made in the public sector. With the completion of the interstate and corridor highways, accessibility will be greatly improved.

In addition, within an hour of driving distance, there are seven annual festivals, with an estimated attendance of well over 500,000 people. Within the area there are 14 major attractions that draw in excess of a million people who are engaged in some type of outdoor recreational activity. Viewed in these terms, the market potential is at least good.

Observations

At this point some preliminary conclusions can be drawn.

1. Principal areas of development are in the:

   a. Mt. Storm, Aurora, Garrett County, Md., areas
   b. Parsons (Tucker County) area.
   c. Bartow area of Randolph County.
   d. Helvitia, Pickent, Kumbrabow area of Randolph, Upshur, and Webster Counties.

   Lesser areas of potential are in the:

   a. Phillippi, Belington area of Barbour County

b. Richwood area of Nicholas County
c. Sugar Grove area of Pendleton County

2. Large number of private owners with relatively small supply of taps and very few landowners interested in producing sap present at least two problems:

a. Central evaporator operator will negotiate with a large number of people for sap supply.

b. Sap production will be the responsibility of the operator.

3. Tap supply on public lands represents a stable source of sap. It follows that this supply might serve as the basis for industry development. Such development should result in additional supplies of sap from small private holdings.

PROGRESS IN THE CHEMISTRY OF MAPLE FLAVOR

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In 1956 at the Third Conference on Maple Products, I presented a paper about the chemistry of maple flavor (4). One of my conclusions at that time was that although knowledge concerning the factors influencing the formation of maple flavorants was being obtained, the scientist was still baffled as to their chemical identity. We were not concerned about this situation, as improvement in maple sirup quality was being accomplished without extensive knowledge of the chemical composition of maple flavor. However, it is obvious that better control of flavor development would be possible with knowledge of the chemical compounds involved. Further, information about the chemical composition could be used to develop tests for quality and purity of maple products. Therefore, interest in the chemical nature of maple flavor has supported a continuing compositional study program on this subject, and since 1956 we have been slowly gaining knowledge about the chemistry of maple flavor.

Certainly all of the constituents of maple sirup contribute to its flavor--the sugar, the dissolved sugar sand, and the oil, butter, or whatever is used as an antifoam agent. However, there is an unknown number of trace materials in the sirup that gives it "maple flavor." These are the chemical compounds about which I am talking today.

Since, like most flavor compounds, these flavorants are present in maple sirup in minute amounts (parts per million), the first step toward identifying them is to isolate them from the other components in an amount large enough for identification tests. In the case of maple sirup, Sair and Snell (3) at McGill University in 1939 used chloroform for this purpose. Comparison of this solvent with others in our first studies showed that it was superior in producing a sugar-free extract and left the extracted sirup devoid of maple flavor.

From 1960-1970, several work projects were devoted to the identification of the compounds in this chloroform extract. Again, the procedure was the isolation of the compounds in the chloroform extract into pure fractions and the identification of each fraction. Progress was made as new, better methods of separation and identification became available. Vanillin and syringaldehyde were found using column chromatography (8). The first work with gas chromatography added dihydroconiferyl alcohol to this list (6). The development of micro techniques in infrared spectrometry, the advent of mass spectrometry, and the advances in gas chromatography increased the number of identified compounds to 25-30 (2), including such flavorful ones as acetol, acetoin, and methylcyclopentenolone (commercially known as cyclotene and sold as an artificial maple-like flavorant). Also, during these studies, a ligneous material

was found in the chloroform extract of the sirup. Its chemical structure has never been determined, but it could be the precursor of such compounds as the vanillin.

During the studies just described, many small peaks on gas chromatograms of the involved chloroform extracts indicated the presence of more flavor components in very small amounts. Therefore, in 1968, the most complete analysis possible was made of the chloroform soluble compounds in maple sirup, utilizing the best techniques of the earlier work (1). A 40-gallon lot of sirup was extracted more rigorously than usual in a glass liquid-liquid extractor so as to obtain a maximum amount of the chloroform solubles. From this work, 55 compounds were isolated and most of them were identified. These compounds can be divided into four groups according to their probable origin: (1) solvent-related impurities, (2) contaminants and artifacts, (3) compounds related to lignin, and (4) compounds related to carbohydrates. Thus it appears that the ligneous material and the carbohydrates in the maple sap are the precursors of the maple flavorants.

Finally, in order to use the knowledge gained from these studies, a procedure was devised from the accumulated information for producing a gas chromatogram depicting the important flavorants in maple sirup (7). A mild chloroform extract of sirup gives a chromatogram with 25 peaks representing such flavor compounds as acetol, isomaltol, cyclotene, α-furanone, hydroxymethylfurfural (HMF), vanillin, syringaldehyde, and dihydroconiferyl alcohol. This maple flavor "profile" was determined for fancy grade maple sirups from five different maple sirup producing areas in the United States. The profiles showed that the chloroform flavor extract is remarkably uniform regardless of the geographic origin of the sirup.

The "maple flavor profile" will also enable us to see how the flavorants are formed and changed during processing. In a preliminary study (5), a typical flavored commercial maple sirup was divided into three portions. The first portion was held untreated, the second was autoclaved for 1.5 hours at 15 p.s.i.g. (250° F.), and the third was autoclaved for 4 hours. The flavor profiles of these sirups showed that the 25 components involved changed in amount. In the light-colored original sirup, acetol and compounds related to lignin (vanillin, syringaldehyde, and dihydroconiferyl alcohol) predominated. As the sirup was heated, carbohydrate breakdown products began to increase until they predominated. These were such compounds as the acetol, furonones, cyclotene, and HMF. As the carbohydrate degradation products increased, the sirup darkened in color and became acrid in flavor; at this point vanillin began to decrease. Using this tool, it would seem possible to establish processing parameters that would control precisely the flavor development in maple sirup.

Literature Cited

(1) Filipic, V. J., Underwood, J. C., and Dooley, C. J.

1969. Trace components of the flavor fraction of maple sirup. J. Food Sci. 34: 105-110.

(2) Filipic, V. J., Underwood, J. C., and Willits, C. O.

1965. The identification of methylcyclopentenolone and other compounds in maple sirup flavor extract. J. Food Sci. 30: 1008-1015.

(3) Sair, L., and Snell, J. F.

1939. Fractionation of the chloroform extract of maple sirup. Can. J. Research 17, B: 281-289.

(4) Underwood, J. C.

1956. The color and flavor of maple sirup. Chemical factors. Report of Proceedings Third Conference on Maple Products, pp. 35-36.

(5) Underwood, J. C.

1971. Effect of heat on the flavoring components of maple sirup. A preliminary study by gas chromatography. J. Food Sci. 36: 228-230.

(6) Underwood, J. C., and Filipic, V. J.

1963. Gas chromatographic identification of compounds in maple flavor extract. JAOAC 46: 334-337.

(7) Underwood, J. C., Filipic, V. J., and Bell, R. A.

1969. GLC flavor profile of maple sirup. JAOAC 52: 717-719.

(8) Underwood, J. C., Willits, C. O., and Lento, H. G.

1961. Maple sirup. XVI. Isolation and identification of compounds contributing to the flavor of maple sirup. J. Food Sci. 26: 288-290.

REGISTRATION LIST

Name	Organization	Address
Adams, Mrs. Cyndy	Smada Farms	Greene, N. Y.
Adams, John	Smada Farms	Greene, N. Y.
Adams, Richard	Rutland County Maple Producers	Cuttingsville, Vt.
Alwin, L. V.	Maple producer	Mound, Minn.
Anderson, Norman	Maple producer	Cumberland, Wis.
Anderson, Mrs. Norman	Maple producer	Cumberland, Wis.
Bacon, Charles W., Jr.		Jaffrey Center, N.H.
Bacon, Mrs. Virginia		Jaffrey Center, N.H.
Bates, Mrs. June		Scottville, Mich.
Bell, Lester E.	Michigan State University	E. Lansing, Mich.
Brookman, Gordon	Maple producer	South Dayton, N. Y.
Carpenter, Leonard	Maple producer	Harbor Springs, Mich.
Carpenter, Mrs. Leonard	Maple producer	Harbor Springs, Mich.
Clark, William S.	Vermont Maple Syrup Mfr's Assoc.	Wells, Vt.
Coombs, Robert	Maple producer	Jacksonville, Vt.
Coombs, Mrs. Robert	Maple producer	Jacksonville, Vt.
Corbett, Charles		Ailsa Craig, Ontario, Canada
Corbett, Mrs. Elizabeth		Ailsa Craig, Ontario, Canada
Crossen, Roger	General Foods Corp.	Battle Creek, Mich.
Croteau, Gilles	Quebec Sugar Makers	Levis, Quebec, Canada
Curtis, Edward A.	Maple producer	Honesdale, Pa.
Danes, A. E.		Toronto, Ontario, Canada
Davenport, Russell	Maple producer	Shelburne Falls, Mass.
Davenport, Mrs. Russell	Maple producer	Shelburne Falls, Mass.
Désilets, Denis	Larel University	Quebec, Canada
Farley, Hilton A.	Maple producer	Middlefield, Ohio
Farrand, E. P.	The Pennsylvania State University	University Park, Pa.
Finyland, John		London, Ontario, Canada
Gabriel, William J.	U.S. Forest Service	Hilton, Vt.
Garrett, L. D.	U.S. Forest Service	Burlington, Vt.
Gibbs, Carter B.	U.S. Forest Service	Orono, Maine
Gilbert, Roy		Galt, Ontario, Canada
Gowen, Gorden	Maple producer	Alstead, N. H.
Gowen, Mrs. Gorden	Maple producer	Alstead, N. H.
Guy, Donald B.	Aqua-Chem, Inc.	Waukesha, Wis.

Name	Organization	Address
Harding, Ted	Maple producer	Athens, Maine
Harding, Mrs. Ted	Maple producer	Athens, Maine
Healey, Terry	Maple producer	Charlevoix, Mich.
Healey, Mrs. Terry	Maple producer	Charlevoix, Mich.
Hodge, John	Michigan State University	Petoskey, Mich.
Humphreys, Walter		Barrie, Ontario, Canada
Humphreys, Mrs. Walter		Barrie, Ontario, Canada
Huyler, Neil K.	U.S. Forest Service	Burlington, Vt.
Huxtable, Robert	Sugar Bush Supplies	Lansing, Mich.
Johnson, Arthur R.	Food & Drug Administration	Washington, D. C.
Johnson, Ture	Farm forester	Burton, Ohio
Kidd, William E., Jr.	W. Virginia University	Morgantown, W. Va.
Kissinger, John C.	Eastern Marketing & Nutrition Research Division, ARS, USDA	Philadelphia, Pa.
LaCrosse, Stanley		Kewaukee, Wis.
Laing, Fred	University of Vermont	Burlington, Vt.
Lamb, Robert	A. C. Lamb & Son	Liverpool, N. Y.
Lamb, Mrs. Florence	A. C. Lamb & Son	Liverpool, N. Y.
Landry, C. E.	Quebec Sugar Makers	Levis, Quebec, Canada
Larson, Herbert F.		Crystal Falls, Mich.
Lesure, Linwood	Maple producer	Ashfield, Mass.
Lesure, Mrs. Linwood	Maple producer	Ashfield, Mass.
Longman, Robert	Maple producer	Petoskey, Mich.
Longman, Mrs. Edith	Maple producer	Petoskey, Mich.
Marvin, David R.	U.S. Forest Service	Burlington, Vt.
Marvin, James	University of Vermont	Burlington, Vt.
Marvin, Mrs. James		Burlington, Vt.
McConnell, R. B.	Maple producer	Coudersport, Pa.
McConnell, Mrs. R. B.	Maple producer	Coudersport, Pa.
Merle, Arthur	Maple producer	Attica, N. Y.
Merle, Mrs. Arthur	Maple producer	Attica, N. Y.
Moore, Floyd	Maple producer	Ocqueoc, Mich.
Moore, Mrs. Kay	Maple producer	Ocqueoc, Mich.
Morrow, Robert	Cornell University	Ithaea, N. Y.
Morrow, Mrs. Robert		Ithaca, N. Y.
Morselli, Mariafranca	University of Vermont	Burlington, Vt.
Peterson, T. A.	University of Wisconsin	Madison, Wis.
Renwick, Walter		Clifford, Ontario, Canada
Reynolds, Adin	Maple producer	Aniwa, Wis.
Reynolds, Mrs. Adin		Aniwa, Wis.
Reynolds, Juan	Maple producer	Aniwa, Wis.
Reynolds, Mrs. Loretta		Aniwa, Wis.
Richards, Paul	Maple producer	Chardon, Ohio

Name	Organization	Address
Running, Eugene	Maple producer	Cambridge Springs, Pa.
Running, Mrs. Eugene		Cambridge Springs, Pa.
Russell, Cleveland	Maple producer	Rome, Pa.
Russell, Mrs. Irene		Rome, Pa.
Schroeder, Henry	Maple producer	Antigo, Wis.
Schroeder, Mrs. Henry		Antigo, Wis.
Scott, Marjorie R.	Quaker Oats Co.	Barrington, Ill.
Sendal, Paul E.	U.S. Forest Service	Burlington, Vt.
Shaw, Ron		Hawkstone, Ontario, Canada
Shaw, Mrs. Ruthanne		Hawkstone, Ontario, Canada
Sipple, Lloyd	Maple producer	Bainbridge, N. Y.
Sipple, Mrs. Lloyd		Bainbridge, N. Y.
Skog, Roy E.	Michigan State University	Marquette, Mich.
Small, Orlando	Maple producer	Farmington, Maine
Small, Mrs. Orlando		Farmington, Maine
Smith, James	Maple producer	Kinsman, Ohio
Smith, Mrs. James		Kinsman, Ohio
Smith, Marvin E.	University of Minnesota	St. Paul, Minn.
Smith, Xura K.	Maple producer	S. Dayton, N. Y.
Statts, Lewis J.	Cornell University	Lake Placid, N. Y.
Steinke, William	Maple producer	Detroit Lakes, Minn.
Steinke, Mrs. William		Detroit Lakes, Minn.
Szymujko, Joseph A.	County forester	Claremont, N. H.
Taylor, Howard	Maple producer	Bainbridge, Ohio
Thackery, Russell H.	Calgon-Havens	Pittsburgh, Pa.
Underwood, J. C.	Eastern Marketing & Nutrition Research Division, ARS, USDA	Philadelphia, Pa.
Vachon, Gaston		St. Jean Baptiste, Quebec, Canada
Vachon, J. M.		St. Jean Baptiste, Quebec, Canada
Walters, Russell S.		Burlington, Vt.
White, J. W., Jr.	Eastern Marketing & Nutrition Research Division, ARS, USDA	Philadelphia, Pa.
Willard, Everett	Vermont Dept. of Agriculture	Montpelier, Vt.
Winch, F. E., Jr.	Cornell University	Ithaca, N. Y.
Winch, Mrs. F. E.		Ithaca, N. Y.
Wright, Leon E.	Maple producer	Franklinville, N. Y.
Wright, Mrs. Leon E.		Franklinville, N. Y.
Yawney, Harry W.	U.S. Forest Service	Burlington, Vt.

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